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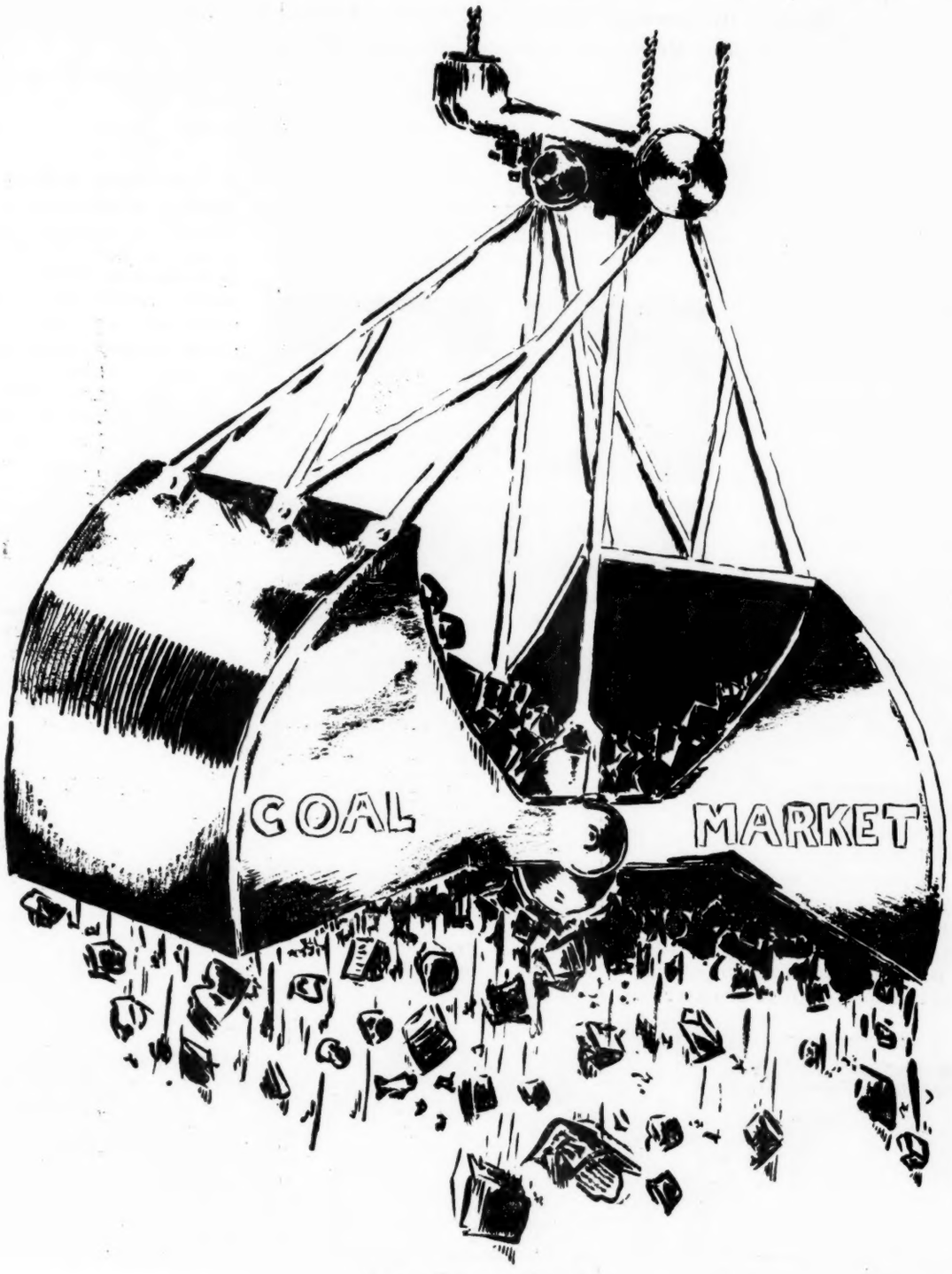

Open and Falling

Contributed by C. H. Bromley

Properties of Arc Metal and Arc Welds as Determined by Tests

Result of Exhaustive Tests on Electric-Arc Metallic-Electrode Welds—Tests Include Tensile, Compression, Cantilever, Transverse, Shear, Impact, Bending and Hardness—Comparisons Are Made Between Properties of Bulk and Layer-Deposited Metal—Microscopic Structure of Welds—Fatigue Resistance Under Repeated Stresses—Magnetic Properties

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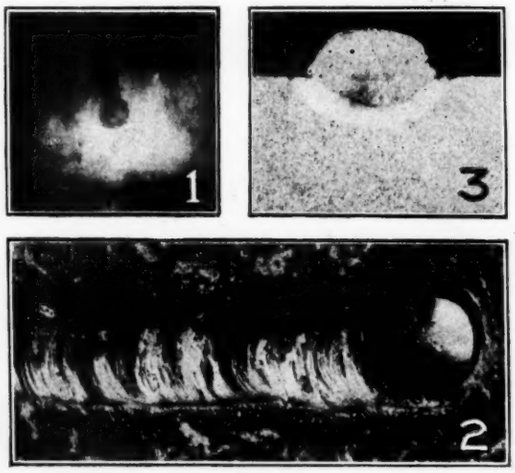
THE process of metallic electrode arc welding requires fusion between the members of a joint and an intermediate casting. It is evident that the weld properties are determined by the characteristics of (1) the original or parent metal, (2) the metal adjacent to zone of fusion, altered by thermal cycle and (3) the arc-deposited metal. Metal deposition is accomplished by transferring small liquid globules from a wire electrode to a crater formed by the arc in the parent metal. By controlling the direction of the arc travel, a sequence of such globules may be fused in layer form to the surface of the scarfed joint or previously deposited metal. In order to build up a surface or completely fill a section, tiers of such parallel layers may be deposited in some predetermined sequence. In Fig. 1 is shown, in exaggerated form, a liquid globule suspended from the end of a wire electrode; in Fig. 2 a typical layer of deposited metal; while in Figs. 3, 4, 5 and 6 are shown sections through single and superposed layers.



FIGS. 1 TO 3. WELDING ARC AND DEPOSITED METAL

Fig. 1—Appearance of welding arc, showing globular formation at end of wire electrode preliminary to deposition. Fig. 2—Layer of arc-deposited metal. Note surface, contour and crater. Fig. 3—Appearance of section through a single deposited layer. Note fusion zone.

It is evident from these illustrations that the completed deposit consists of an aggregate of fused globules. For every pound of metal cast when using a bare, low-carbon steel electrode, ⅛ in. in diameter and 150-ampere arc current, it is estimated that roughly 30,000 globules are transferred. These attain a temperature of about 2,000 deg. C. at the wire electrode arc terminal, then pass across the arc stream, subject to more or less attack by enveloping gases, to be deposited finally on a surface previously liquefied by the energy developed at the positive arc crater. Owing to the relatively high thermal capacity of the joint members the deposited metal is cooled at a very rapid rate, analogous to that of quenching. The effect of superposing deposits is to partly anneal preceding quenched deposits. It is evident that metal so formed may possess properties differing from those of steel cast in large masses, subjected to mechanical working, and then a prescribed heat treatment. It is also conceivable that changes in arc-metal properties may be achieved by modifying arc and electrode manipulation, electrode constituents, arc gases and circuit characteristics. The evaluation of these factors may be expedited by confining test observations to the properties of the deposited metal, thereby eliminating the many variables introduced by the characteristics of the shank metal, type of joint and the character of fusion that exists between the deposited and the original plate metals being welded.

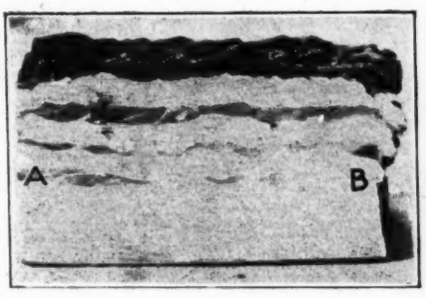


FIG. 4.
Longitudmal section through superposed layers showing fusion pattern between layers parallel to direction of deposition, *A-B*

FIG. 5.
Section through built-up layers showing character of fusion pattern transverse, *C-D*, to direction of deposition.

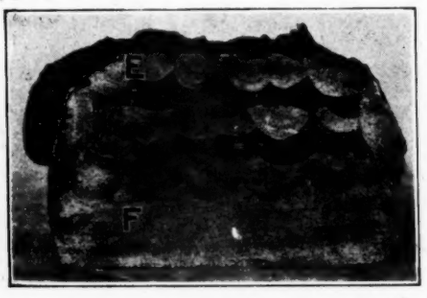


FIG. 6.
Section through built-up layers, illustrating character of fusion axially, *E-F*, to direction of deposition.

The preferred method for building up a surface or filling in a joint is to deposit the arc metal in layers and tiers. The *fusion patterns* obtained between adjacent layers are clearly shown in Figs. 4, 5, and 6. To facilitate the reproduction of the appearance of these surfaces, it was found desirable to employ two electrodes, one of low- and the other of high-carbon content, so that the different layers would be clearly indicated by their difference in reaction to the etching fluid. The dark areas represent sections through layers deposited from 1.25 per cent carbon electrodes and the light areas similar sections deposited from 0.18 per cent carbon electrodes.

TABLE I. PROPERTIES OF ARC-DEPOSITED METAL

Metal Constituents:	C.	Mn	S	P	Fe
Analysis of wire electrode, per cent	0.16	0.56	0.024	0.032	99.2
Analysis of deposited metal, per cent	0.05	0.19	0.013	0.024	99.7

Tensile:

Deposit Fig. 7	Pounds per Square Inch — U.T.S.	Yield Point	Elastic Limit	Per Cent Elongation in 2 In.	Per Cent Red. of Area
A	56,100	33,400	27,500	18.1	30.8
	56,075	35,875	29,000	16.0	23.4
	58,225	.....	.....	18.0	27.8
B	51,375	29,050	24,000	14.1	18.8
C	40,875	29,400	24,250	4.4	15.9
	43,500	28,900	20,000	4.9	7.0

Compression:	Load at 10 per Cent Compression Lb. per Sq.In.	Elastic Limit Lb. per Sq.In.
A	63,250	32,000
B	60,750	30,700
C	60,700	30,400

Cantilever:	Ultimate Stress Lb. per Sq.In., 6-In. Arm.
A	64,600
B	63,400
C	61,000

Transverse	Elastic Limit, Lb. per Sq.In. (6-In. Between Supports)
A	27,850
B	28,000
C	28,500

Shear:	Stress at Shear, Lb. per Sq.In.
A	39,200
B	41,450
C	38,500

Impact, Izod:	Foot-Lb. to Fracture Standard Notched Specimen Test No. 1	Test No. 2	Test No. 3
A	1.5	1.5	1.5
B	1.5	1.0	1.5
C	1.0	1.5	1.5

Bending:	Distance D in Inches as per Fig. 9 at Fracture
A	0.625
B	1.00
C	1.25

Hardness: Brinell, No. 114.

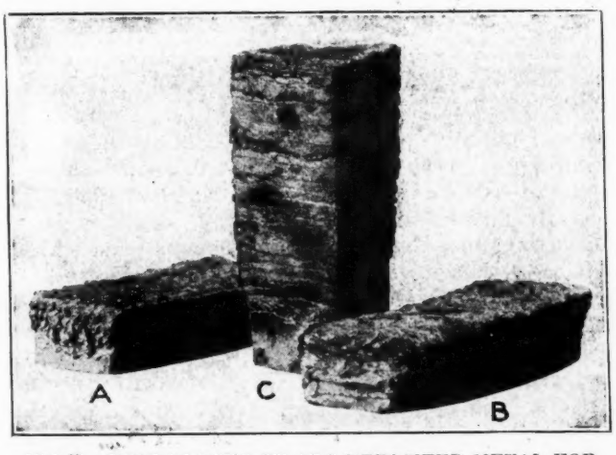


FIG. 7. TEST BLOCKS OF ARC-DEPOSITED METAL FOR THE PURPOSE OF DETERMINING RELATION BETWEEN PHYSICAL PROPERTIES AND DEPOSITION DIRECTION, TABLE I

A—Test pieces cut and stressed parallel to direction of deposition, *A-B*, Fig. 4. B—Test pieces cut and stressed transverse to direction of deposition, *C-D*, Fig. 5. C—Test pieces cut and stressed axially, *E-F*, Fig. 6.

From these patterns it will be noted that if load is applied in the direction of *AB*, Fig. 4, or in line with the direction of deposition, the fused zones are stressed in parallel. However, if load is applied in the direction *CD*, Fig. 5, or transverse to the direction of deposition, the zones of adjacent layer fusion are stressed in series. If the load is applied along *EF*, Fig. 6, or axially, the zones of fusion of superposed layers are stressed in series. To determine the relation between stress and direction, metal was deposited, Fig. 7, on a plate ½-in. thick, using a ⅛-in. mild-steel electrode, 175 amperes, short-arc length and the surface of each layer cleaned before forming the next layer. After normalizing each sample, by holding at 1,650 deg. F. for 15 min. and cooling in air, the base plate was removed and the following test pieces cut: (1) Standard A. S. T. M. 2-in. gage length, 0.505-in. diameter tensile-test specimen; (2) 2½-in. long, 0.798-in. diameter compression column; (3) ¼ x ½ x 9-in. bending, transverse and cantilever test specimens; (4) one centimeter square notched Izod Impact test specimen.

FIG. 8. APPEARANCE OF FRACTURE OF TENSILE-TEST SPECIMEN

Specimen stressed parallel to direction of deposition, U. T. S. —58,225 reported in Table I. Note raggy, angular fibrous fracture similar to that obtained with annealed low carbon cast steel.

In Table I are given the properties of arc-deposited metal with reference to the direction of deposition. An inspection of this table shows that the best results are obtained when depositing the metal in the direction of stress (sample *A*, Fig. 7). The greatest variation in properties is secured when subjecting the material of the various specimens to a tension stress. When the direction of stress is parallel to the direction of deposition, as in *A*, Fig. 7, the number of fused zones stressed in series is a minimum, while when the direction of stress is axially, as in *C*, Fig. 7, the number of fused zones in series, as well as slag pockets, is a maximum. It is interesting to note that the results for sample *B*, which represents the condition existing in most welding, is intermediate between *A* and *C*. These data suggest that the metal deposited should be formed in a direction so that the *greatest stress will be parallel to the direction of deposition.* When this is not possible, the number of layers in series, case *B*, may be reduced by widening the deposit. Since these observations represent the limitations of the operator as well as those of the process, improvement in either will tend to better the properties of metal formed in sample *B* and *C*.

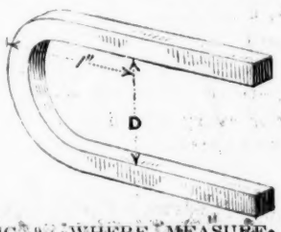


FIG. 9. WHERE MEASUREMENTS OF BENDING TESTS WERE TAKEN

In the building up of heavy sections it is usual practice to deposit alternate tiers at right angles. It is evident that this method should give results intermediate between those obtained with samples *A* and *B*, Fig. 7. The characteristics of a 14-lb. deposit built up in such a manner are given in Table II. A section through the deposit is shown in Fig. 11, and although

TABLE II. PROPERTIES OF ARC-DEPOSITED METAL WHEN LAYERS OR SUPERPOSED TIERS ARE DEPOSITED AT RIGHT ANGLES

Pounds per Square Inch			Per Cent	Per Cent
U. T. S.	Yield Point	Elastic Limit	Elongation in 2 In.	Reduction of Area
58,825	41,000	34,500	9.2	19.9
54,650	35,000	29,000	6.5	13.4

Compression: Elastic Limit, Lb. per sq.in., 29,450 and 34,500.
Hardness: Brinell No. 114.
Shear: 46,200 and 44,600 lb. per sq.in.
Bending: 100 deg. on 1 in. radius, bar ½-in. thick.
Impact Izod: Unannealed specimens 2,2 and 1 foot pounds.

the surface is not free from minor flaws, there are no large blowholes or slag pockets present.

While experience has shown that layer deposition partly anneals the weld, facilitates slag flotation and reduces slag pockets, there are still many operators who completely fill the section between joint surfaces as they progress along the seam without regard to the form

TABLE III. TENSILE PROPERTIES OF ARC METAL FORMED BY BULK DEPOSITION

Pounds per Square Inch			Per Cent	Per Cent
U. T. S.	Yield Point	Elastic Limit	Elongation in 2 In.	Reduction of Area
35,375	22,500	19,000	3.6	10.8
31,875	22,000	20,000	3.2	9.3
Ratio of average results obtained from bulk deposition to Average Results, A and B, Table I and Table II, from layer deposition, per cent:				
60	64	65	24	45

of the deposit. This procedure may be termed bulk deposition. The test results from a number of deposits formed in this manner are given in Table III.

This comparison shows clearly that a marked reduction in strength and ductility occurs when the arc metal

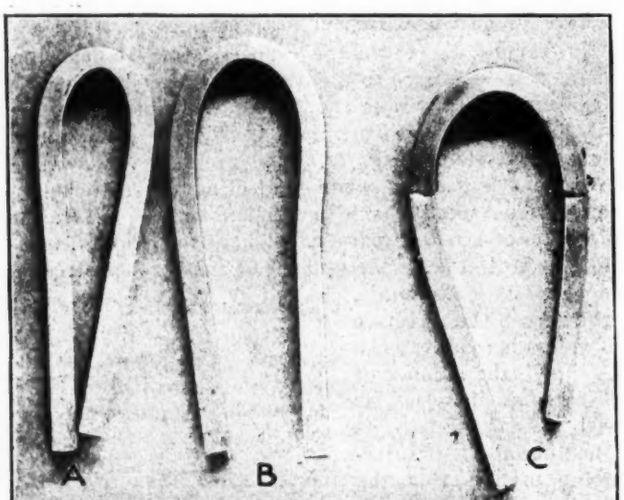


FIG. 10. APPEARANCE OF BENDING-TEST SPECIMENS TAKEN FROM TEST BLOCKS *A B C*, FIG. 7, SHOWING INHERENT DUCTILITY OF ARC-DEPOSITED METAL

is deposited in bulk rather than in layer form. It is evident that difference in procedure in the deposition of arc metal may easily account for the differences in results obtained in both commercial and experimental welding.

On page 681 of *Chemical and Metallurgical Engineering*, Oct. 6, 1920, are given the tensile properties and hardness of twenty-three specimens of arc-deposited metal, determined by the United States Bureau of Standards, from bare electrodes. Each specimen was prepared by layer deposition, as shown in Fig. 13. The average results, indicative of arc-deposit properties under normal conditions at the present stage of the process development, are given in Table IV. These values are appreciably lower than those given for the larger test desposits *A*, Table I.

The data of Tables I, II and IV show that the properties of arc-deposited metal in general approximate those

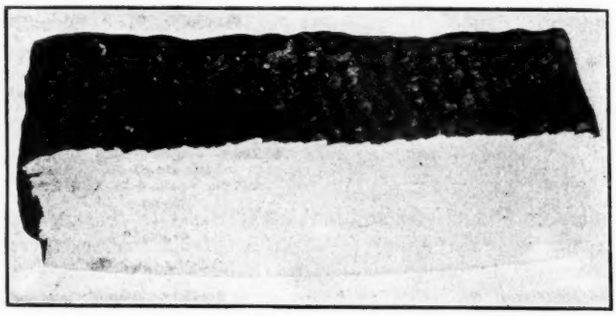


FIG. 11. SECTION THROUGH 14-LB. BLOCK OF ARC-DEPOSITED METAL. TEST RESULTS GIVEN IN TABLE II

of an ordinary grade of low-carbon boiler plate or unannealed low-carbon cast steel. Values for the ultimate tensile strength of 58,000 lb. per sq.in. represent approximately the maximum when employing low- or mild-carbon content bare electrodes. Values of the order of 50,000 lb. per sq.in. should be readily obtained in practice. The ductility of the metal depends to a considerable extent upon the degree of slag inclusion. As

TABLE IV. AVERAGE OF RESULTS ON ARC-DEPOSITED METAL OBTAINED BY THE BUREAU OF STANDARDS

Pounds per Square Inch			Per Cent	Per Cent	
U. T. S.	Yield Point	*Prop. Limit	Elong. in 2 In.	Red. of Area	Brinell Hardness
49,220	34,370	25,453	9.2	10.6	108

* The term "Elastic Limit" has so many interpretations that confusion has resulted. In an effort to clear up the situation, the Bureau of Standards employs the term "Proportional Limit," abbreviation "Prop." This is the load per unit of original cross-section at which the deformations cease to be directly proportional to the loads. Elastic limit is the greatest load per unit of original cross-section, which does not produce a permanent set. It will be seen that there is not much difference between these two. However, the elastic limit is most frequently measured by the Johnson method, and is slightly higher than the proportional limit, as determined by the Bureau of Standards.

shown, however, by the fracture exhibits in Fig. 8, bending-test specimens, Fig. 10, and compression- as well as tensile-test specimens, Fig. 12, the metal is inherently ductile provided a short-arc length is maintained, layer-deposition procedure followed and each tier of layers cleaned before applying a second tier.

The metal deposited from bare low-carbon steel electrodes shows the irregular polyhedral grain structures typical of low-carbon unannealed cast steel, with the presence, however, of varying quantities of oxides and nitrides. Fig. 14 shows, in exaggerated form, a section in which these slag occlusions are present. This deposit was produced with a Norway iron electrode using a long arc. The extent to which such impurities occur varies with the electrode characteristics and arc manipulation. The relative low ductility of some arc-deposited metal is usually ascribed to the presence of these impurities. A comprehensive discussion of such characteristics is given in an article on "Metallography of Arc-Fused Steel," by Messrs. Rawdon, Groesbeck and Jordan, in *Chemical and Metallurgical Engineering*, Oct. 20, 1920.

Figs. 15 and 16 are two micrographs taken by N. B. Pilling[1] from a small block of metal deposited from bare

[1] Westinghouse Research Laboratory.

mild-steel electrodes. In discussing these exhibits Mr. Pilling states that:

> In its general features the microstructure of the metallic mass is a fine-grained aggregate of the interlocking columnar type, characteristic of rather quick cooling from fusion. Oxide globules are present both as large solid particles and to a lesser extent spherical shells inclosing a metallic globule, both of which are doubtless serious factors in the impairment of ductility.
>
> The more minute details of structure are shown in the micrograph at 1,000 diameters. There are four principal structural entities: (1) A ferrite matrix; (2) a small amount of pearlite; (3) numerous iron nitride needles; and (4) a profusion of emulsified iron oxide. It is perhaps worth noting that the total iron-oxide content occurs in roughly equal proportion in two distinct degrees of dispersion, the physical effect of which would very likely be quite different.

Where the weld is to be subjected to merely a static load, the micro imperfections appear to be chiefly of academic interest. However, where the material is to be stressed under dynamic load, the significance of this unsoundness should be given further study.

Fatigue Resistance

The failure of metal under repeated stress is now attributed to its fatigue. Such failures are characterized by very small elongations and sudden fractures. The apparent primary cause for fatigue failure is localized deformation, produced by sustained and repeated localized pressure or stresses. While little information is available concerning the fatigue-resisting properties of metals, nevertheless it is conceded that the presence of microscopic flaws such as laps, foreign bodies, blowholes, snowflakes and cracks produce progressive development of cracks and slip bands.[2] A linkage or growth of these under repeated stress causes the ultimate failure by fatigue.

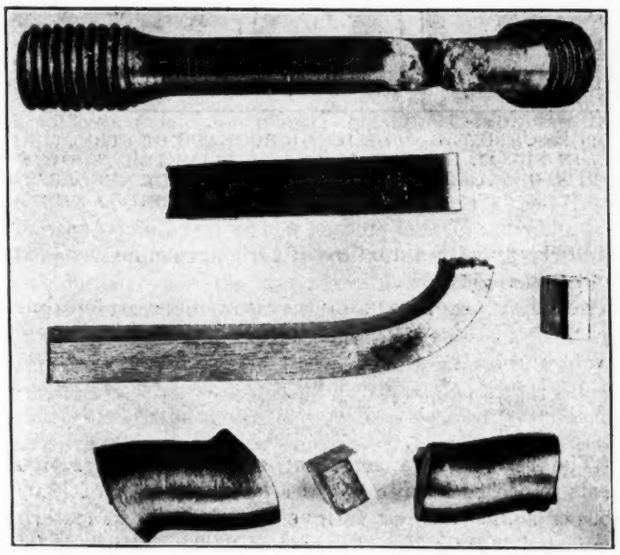


FIG. 12. APPEARANCE OF CHARACTERISTIC TENSILE, SHEAR, BENDING, COMPRESSION AND IMPACT SPECIMENS FROM DEPOSIT, FIG. 1, AFTER TEST

In Table I are published, for the first time, the results of the single-blow notched-bar impact test on arc-deposited metal. This test discovers in a material faults not shown by the usual static tests, metallographic examination or chemical analyses. It appears to give a measure of the toughness of the material and an indication of its fatigue-resisting properties. The highest consistent value the writer has obtained on the impact test of a notched arc-deposited specimen is 2 ft.-lb. This compares with raw cold-rolled steel at 2.5 ft.-lb., and chrome-molybdenum heat-treated spring steels at 27 ft.-lb. Since specimens are easily prepared and the test simple, further examination of arc metal by this method should facilitate investigation of important properties, and perhaps the improvement of the metal.

Arc metal is deposited in small liquid globules under conditions that facilitate the inclusion of slag and gas pockets as well as a variation in the degree of fusion and form of physical structure. The presence of microscopic flaws in such metal, and therefore low resistance to repeated stress, is to be assumed. Available test data comparing the fatigue performance of welded and unwelded metal are too incomplete to warrant the drawing of definite conclusions. It is, therefore, advisable for welding engineers to scrutinize carefully each live-load application and, where permissible, design the joints or reinforce the weld so as to reduce unit stresses at the welded area and transfer the load to a stronger member. Furthermore, it is now recognized that the crystal structure, as well as the chemical analysis of deposited metal, may differ radically from that of the adjacent parent metal. Such differences present additional justification for hesitancy in subjecting arc-welded structures to rapidly alternating stress, unless the stress values are quite low. While, from theoretical considerations, a strong case can be prepared, warranting a close scrutiny of all arc-welding applications sustaining a live load, it should be borne in mind that many successful welds have been made for such applications as locomotive parts, ship plates, street-car trucks, etc., where the cycle of stress reversal has a low period.

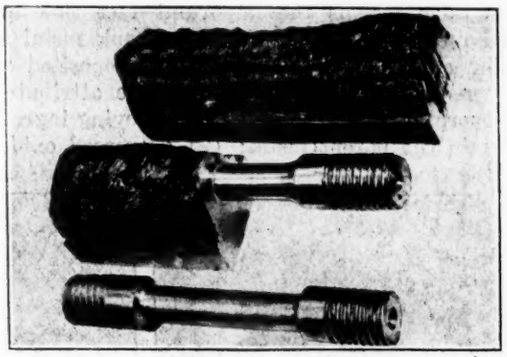


FIG. 13. METHOD OF PREPARING TENSILE-TEST SAMPLES OF ARC-DEPOSITED METAL FOR U. S. BUREAU OF STANDARDS TEST, TABLE IV

Magnetic Properties

Since this process is frequently employed in the repair and production welding of yokes, poles, frames, etc., of electrical apparatus, a comparison is given in Table V of its magnetic properties with those of cast steel.

TABLE V. COMPARISON OF MAGNETIC PROPERTIES OF ARC-DEPOSITED METAL AND CAST STEEL

	Arc-Deposited Metal	Cast Steel
Hysteresis loss, ergs per cu.cm. B = 10,000 gausses	19,100	7,630
Max. permeability (both at 8,000 gausses)	658	1,525
Permeability for B-10,000 gausses	613	1,280
Coercive force for B-10,000 gausses, gilberts per cm	6.80	2.16
Retentivity for B-10,000 gausses, gausses	7,600	8,100

The writer has frequently observed that although the characteristics of deposited metal are the determining

[2] "Fatigue of Metal Under Repeated Stress," H. F. Moore and J. B. Kommers, *Iron Age*, June 3, 1920.

factors in a weld nevertheless the properties of the parent metal have an important bearing on the ultimate characteristics of the joint. In Table VI are compared the tensile properties of welds made with approximately the same manipulation, the same types of electrodes, but with different parent metal. All of these welds were machined and failed in the deposited metal.

TABLE VI. INCREASE IN WELD STRENGTH WITH INCREASE IN STRENGTH OF PARENT METAL

Parent metal:	Shank Metal U.T.S.	Weld U. T. S.
Mild, open-hearth, hot-rolled steel, 0.15 per cent C	50,000	49,660
Ship plate, 0.30 per cent C	64,700	62,600
High-carbon steel, 0.85 per cent C	100,000+	70,000

This table reveals the important fact that arc-deposited metal fused to a stronger shank metal shows superior characteristics to the pure deposited metal. The increase of joint strength may be attributed to: (1) Absorption by hot cast metal of alloying ingredients present in the parent metal; (2) decreased oxide and nitride content in the region of fusion, due to an increase of arc enveloping gases caused by the alloying ingredients; (3) improved fusion at scarf surface, due to lower melting point of parent metal; (4) difference in stress distribution.

FIG. 14. SECTION THROUGH ARC-DEPOSITED METAL, 500 DIAMETERS. NOTE LARGE QUANTITIES OF OXIDE AND NITRIDE NEEDLES

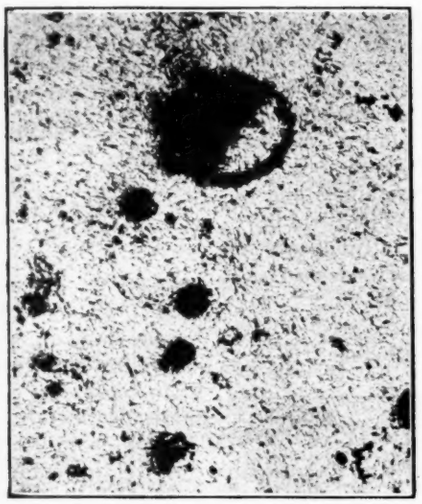


FIG. 15. MICROSTRUCTURE OF METAL FROM BLOCK SHOWN IN FIG. 11, 100 DIAMETERS. NOTE OXIDE GLOBULES AND OXIDE FILMS

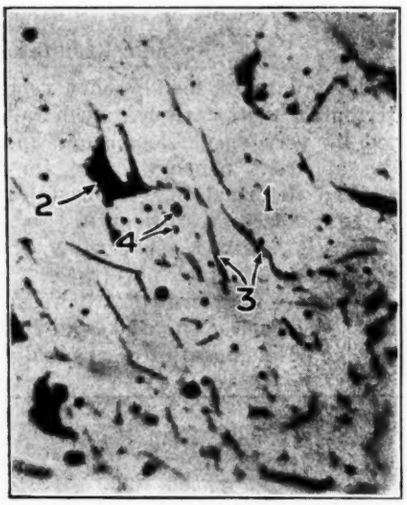


FIG. 16. MICROGRAPH OF STRUCTURE, FIG. 15, AT 1,000 DIAMETERS, SHOWING PARTICULARLY NITRIDE NEEDLES OR PLATES AND EMULSIFIED OXIDES

At the June, 1919, meeting of the American Society for Testing Materials, F. M. Farmer described a machine for the measurement of the fatigue resistance of arc welds, reporting that "the general order of the results so far obtained at 25,000 lb. per sq.in. maximum fiber stress is about 500,000 revolutions for specimens with joints and 10,000,000 revolutions for specimens without joints, or a proportion of 1 to 20."

The use of bare alloy electrodes offers interesting possibilities. Tool-steel shanks of 0.47 carbon, 0.85 manganese, 1.05 chromium, 0.18 vanadium content were welded, using a bare electrode containing 0.25 carbon, 3.35 nickel and 0.65 manganese. The joint was heated to 800 deg. C., quenched in water and drawn at 580 deg. C. The analysis of the arc-deposited metal gave 0.10 carbon, 3.31 nickel and 0.37 manganese. The ultimate tensile strength of the machined joint was 83,700 lb. per sq.in. and the elongation approximately 5 per cent in one inch. The fracture was very ragged, failure occurring chiefly through the parent metal adjacent to the zone of fusion. This value does not represent the limit in strength obtainable with bare electrodes. It is anticipated that with the careful selection of parent and electrode materials, as well as welding procedure, further improvement will be secured.

A discussion of arc-metal characteristics is incomplete without at least a brief reference to the properties of metal deposited from covered electrodes. The presence of microscopic slag inclusions on welding with bare electrodes has suggested to numerous individuals various means for inclosing the arc stream and hot deposited metal with an envelope of relatively inert gases and vapors. Electrode coatings, developed with this object in view, are used extensively in England. Arc deposits from such electrodes appear to give a superior fatigue-resisting performance.

In Table VII[1] are shown the results of tests on arc metal obtained from a mild-carbon steel electrode covered chiefly with a mixture of carbon, calcium carbonate and water glass.

TABLE VII. PROPERTIES OF ARC-METAL DEPOSITED FROM COVERED ELECTRODES

U. T. S.	Elastic Limit	Per Cent Elongation in 8 In.
61,000	47,800	8.5
58,000	45,600	17.5
51,600	40,000	19.0
52,200	26,000	19.2

The results of a series of rotary bending fatigue tests indicated infinite life at a bending stress of 18,000 lb. per sq.in. Similar fatigue tests on welded material indicated infinite life at stress of 24,000 lb. per sq.in.

In Tables VIII and IX are given the average results of tests made for "Lloyd's Register of Shipping," by David Kirkaldy & Sons, London, on arc-deposited metal and ship-plate welds using asbestos-covered electrodes.

TABLE VIII. AVERAGE RESULTS OF TENSILE TESTS ON WELDS AND ARC METAL WHEN USING ASBESTOS-COVERED MILD-STEEL ELECTRODES

Specimen:	Pounds per Square Inch U. T. S.	Yield Point	Per Cent Elong. in 8 In.	Per Cent Red. of Area	No. of Tests
Unwelded	62,000	....	28	45	4
Welded	60,400	....	18	35	8
Arc-deposited metal *	64,500	44,600	13	21	2

* Modulus of elasticity of arc-deposited metal by 27,000,000. Modulus of elasticity of mild steel 30,000,000.

[1] *The Engineer*, Oct. 31, Nov. 7, 1919.

In Table IX are given the results of alternating-stress tests on welds made with asbestos-covered electrodes. In these tests the butt weld in a circular bar was submitted to a continued bending stress in one direction and the bar rotated at a speed of 1,000 revolutions per minute.

TABLE IX. ALTERNATING-STRESS TEST 1,000 R.P.M., ¾-IN. DIAMETER ROUND BAR, ON WELDS MADE WITH ASBESTOS-COVERED ELECTRODES

Specimen	Stress at Periphery Lb. per Sq.In.	Rotations	Remarks
Unwelded	± 23,500	5,000,000	Fractured
Welded	± 14,000	4,355,000	Fractured
Welded	± 14,000	5,000,000	Unbroken
Welded	± 18,800	5,000,000	Unbroken
Welded	± 18,800	1,705,000	Fractured
Welded	± 20,500	1,510,000	Fractured

While an improvement in physical properties can be obtained through the employment of suitably covered electrodes, their proper use requires a high degree of skill to assure consistent fusion and slag removal. The advantages of the covering will perhaps become more pronounced if applied to alloy steels, since the gas envelope obtained will permit the transferance of such important constituents as carbon, nickel, chromium, vanadium, etc., in appreciable quantities.

Summary

The properties of metal deposited from bare electrodes are dependent on the relation of stress and deposit direction as well as on deposition procedure. The greatest resistance to stress is obtained when the load is applied parallel to the direction of layer deposition, and the least when the load is axial to the direction of deposition. Layer deposition procedure may give ultimate tensile strengths 60 per cent greater than bulk deposition. The arc-deposited metal is inherently ductile provided a short arc length is used, the surface of deposits cleaned and the metal annealed.

The presence of small quantities of iron oxide and nitride does not appear to greatly affect the properties of the metal when stressed by a static load. It is assumed, however, that low fatigue- and impact-resisting qualities are caused chiefly by these inclusions. The single-blow notched-bar impact test is suggested as a rapid and convenient means for assisting in the determination and improvement of such properties as toughness and fatigue resistance.

With the use of a given deposition-electrode material and arc manipulation the weld properties are dependent upon the characteristics of the shank or parent metal. Upon changing the material of the weld shanks, the weld strength was increased from 49,000 to 70,000 lb. per square inch.

The field of bare alloy electrodes presents interesting development possibilities, as a weld made with nickel-steel rods gave an ultimate tensile strength of approximately 84,000 lb. per sq.in., fracturing chiefly in the parent metal.

The covered electrode has a promising future, particularly if the covering is developed to give but a slight slag residue and applied to alloy steels. Welds and deposited metal made with covered mild-carbon steel showed maximum tensile properties and fatigue resistance somewhat superior to those of bare electrodes of same analysis.

Causes of High Pressure in Refrigeration Systems

BY V. D. FROID

I WAS fresh from school and thought I knew all that was to be known about refrigeration, so when I went to work in a small plant I approached the job with all the confidence in the world. To check up my knowledge of operation the boss asked me what I would do in case I saw the head pressure going up over two hundred pounds and where I would look for trouble.

Experience afterward showed me that several things could be done, but the most sensible thing would be to shut down the compressor and investigate. As it was, I had to depend on the knowledge gained in school, so replied that I would look at the condenser water supply for the trouble. My answer satisfied the boss. Since that time I have never met with a case of high head pressure due to lack of condensing water. Doubtless there have been such instances, but my own experience has been free from them.

Causes of High Head Pressure

A summary of the causes of excessive head pressures might be made as follows: (a) Foreign gases in the system and scarcity of water, dirty condensers; (b) too much ammonia in the system; (c) stoppage in the discharge line.

By excessive pressure is meant a head pressure that is considerably higher than that to be expected when the temperature of the condensing water and the type of condenser are considered. With atmospheric condensers, in the summer time the head pressure usually corresponds to a condensing temperature from 5 deg. to 10 deg. F. higher than the average water leaving the condenser. With double-pipe condensers the pressure corresponds to a temperature more nearly approaching that of the discharge water.

Foreign gases and dirty condensers cause chronic higher pressures than would be indicated by this rough rule. Such excessive pressures may be looked for in badly run plants and in those plants having poor condensing-water conditions. The remedy is to purge and to keep the condenser surfaces clean.

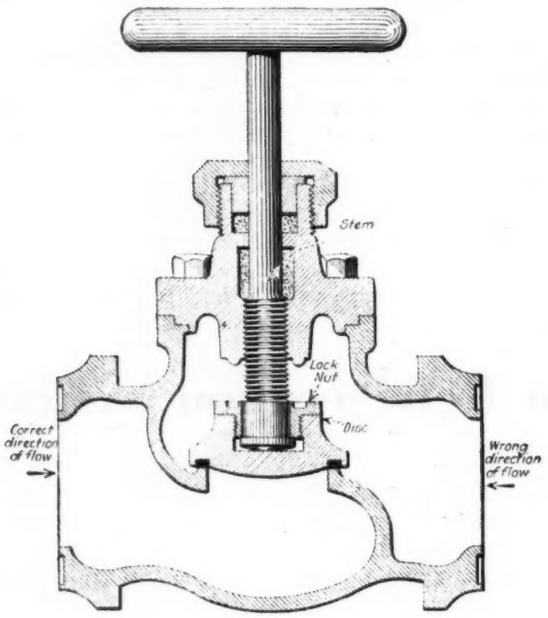
Excessive Ammonia Charge

It is more usual to find refrigerating plants undercharged with ammonia than overcharged. Occasionally, however, the latter condition prevails. A small charge leads to inefficiency; an overcharge leads to dangerous pressures on the high side of the system.

In the first plant that I helped to erect the coils were arranged on the direct-expansion system. The condensers were of the double-pipe type. Such condensers, while efficient as to heat transfer, have small ammonia capacities. The annular space between the 1¼-in. water pipe and the 2-in. outer pipe is all that is reserved for the gas and liquid. In this particular plant the liquid receiver was small. On starting up we tried to put in the whole charge of ammonia before the brine was cooled down to the operating temperature. We could not get the full charge in, but we did get in more than was healthy under the prevailing conditions. To make matters worse, the chief erector took a day off and left me in charge. Everything was going along smoothly, the brine temperature was coming down and I was con-

gratulating myself on my work when in stepped the chief engineer of the company installing the plant. I guess he was curious to see how much I knew about my business and about running a Corliss engine, so he had me stop and start the machine, with all the attendant valve opening and closing. After a while he was satisfied with his examination and, to my intense relief, went on his way.

I congratulated myself on the good impression I had made, but found that all is not gold that glitters. One of the helpers came and told me there was a leak on one of the flanged joints of the condensers. I grabbed a wrench and soon had the leak stopped. But there was another leak on one of the condenser stuffing boxes. This seemed strange because up to that time there had been only two leaks in all the pipework of the plant. But I persevered and tightened up on the gland until



METHOD OF CONNECTING VALVES

that leak was stopped. The helper next reported a leak around the liquid-level gage on the receiver. As soon as I looked at the glass I knew what was wrong. I didn't stop to tighten up either, but ran to the throttle and stopped the engine driving the compressor, and none too soon. The hand on the high-pressure gage was all the way around against the stop, and that gage registered as high as 350 lb. per sq.in. As soon as I had the throttle closed I ran to the brine tank and opened the expansion valves wide. This allowed the liquid to blow over from the high side to the low side and relieve the pressure before any damage was done.

What had happened was this: When I shut down the engine for the chief engineer I had closed the expansion valves. On starting up again I had failed to open the expansion valve wide enough, and the compressor pumped the ammonia into the condenser slightly faster than the liquid could get out of the high side through the expansion valves to the low side. The liquid accumulated in the receiver until that was full, then built up in the condenser, gradually cutting off the condensing surface and causing the high pressure.

That lesson has never been forgotten by me. Recently a friend who operates a small plant called me up and complained of high pressure. Water was flowing over the condensers and he was at a loss to know what was wrong. In answer to a question as to what unusual thing had recently been done in the plant, he replied that he had just charged in a couple of cylinders of ammonia. I knew the answer, and told him he had too much ammonia in the system. He took out one cylinderful and his high pressure dropped to normal.

Obstructed Discharge Line

One would not expect that a stoppage in the discharge pipe would occur very often. Yet it has been my experience that such stoppages occur comparatively frequently, and invariably at a valve. Most engineers have a justified dread of starting up a compressor with the discharge stop valve closed. Accidents in the past have often been caused by this lack of an open valve. A safety valve with its inlet connected below the discharge stop valve and its outlet to the suction pipe above the suction stop valve is the usual means taken to prevent such an accident. There really is no excuse for a plant being operated without such a protecting safety valve.

Frequent causes of discharge-pipe stoppage lie in the construction and method of installation of ammonia stop valves. The disks of such valves are independent of the stem. These disks swivel around the stem and are held thereto by means of a locknut. If the locknut should loosen—and it will oftener than one would suppose—the disk will be free of the stem. If the valve should be set into the pipe line with the flow down through the valve seat, there will be a stoppage if the disk works loose. The illustration shows the proper and the improper way to install a valve. Such a stoppage in the suction line will be most puzzling, but not necessarily dangerous. In the discharge line there is great danger of an accident unless the machine is protected by a safety valve.

I recall stoppages of this nature at least five times in my experience—one in the suction line and four times in the discharge line. In the case of the suction-pipe stoppage, which occurred in a plant using the flooded system, the deranged valve was between the accumulator and the coils. As a result the system failed to function.

The cases of the discharge-valve stoppages were more serious. One was discovered during erection. One was in the discharge line a considerable distance from the compressor. Every time the machine was started the head pressure rapidly built up to an alarming extent. The engineer was on the job and shut down in time. Although it took a couple of days to discover the cause no damage was done to the system. In a third case the valve was the main discharge stop valve. There was no safety valve. The erector on the job did not notice the high pressure and an accident occurred. It happened that the weakest link was the crosshead. This let go, but no other damage was done, except to the erector's reputation. He broke another crosshead before he located the difficulty. The most serious of these accidents occurred in a machine that had been operating for years and was running at full speed at the time. The result was that the top head fractured; the safety head could not save it.

To avoid such accidents the valve should be made so that the disks cannot get free from the stem, and also the valves should be inserted in the pipe lines so that the pressure comes *under* the seat, as is usual in all well-designed pipe lines.

Chimneys—Practical Features of Design*

Causes Tending to Destroy Chimneys—Effects of Wind Pressure—Location of Center of Wind Pressure—Sustaining Ability of Soil—Graphic Method of Determining Stability of Chimneys

BY HERRELL CROFT

A CHIMNEY may be built either of masonry, steel or concrete. Each of these materials has characteristics that adapt it for certain applications, but which may render it unfit for others. Often it is a matter of choice as to the material that should be used. But usually there is a good reason, economic or otherwise, for utilizing a certain material. The safe stresses shown in Table I should not be exceeded.

The principal agents tending to destroy a chimney are the weather (including the wind), heat and the gases of combustion. The rain and atmospheric and temperature changes tend to wear away the outside of the chimney. Masonry structures, if properly designed, withstand successfully these destructive elements. Dampness and temperature changes render it difficult to prevent corrosion of a steel stack. However, if the steel is well protected by a suitable paint, there will be little external corrosion. The interior of the steel stack and the seams may be attacked by certain of the products of combustion. The most important of these is sulphur dioxide. A portion of it is converted to sulphuric acid, which "eats away" the steel.

A masonry stack, being thick, is relatively cool on the outside, while at a comparatively high temperature on the inside, due to the hot gases. This has a tendency to expand the interior of the chimney more than the outside, thereby pulling apart the exterior of the wall, and may result ultimately in considerable weakening of the structure. In concrete chimneys it is found that gases, which always carry moisture, are, in passing up the stack, chilled by the relatively cool wall. The moisture is then condensed on the interior of the wall. It enters the fissures and may attack the reinforcing bars.

All of these interior destructive tendencies, regardless of the material of the stack, are practically avoided by a suitable lining, which may be of concrete, common brick or firebrick. When the stack is thus lined, it has to withstand only the wind pressure and the destructive tendencies of the natural elements.

The elevation to which a chimney lining should extend may vary from about one-fifth of the height to the total height of the structure, depending upon the temperature of the gases entering the chimney and the material of which it is built. If the gases are relatively cool, say 300 to 500 deg. F., the lining need not extend to any great height, or there may be none. But if the temperature is high, say double that specified, the lining should be extended correspondingly.

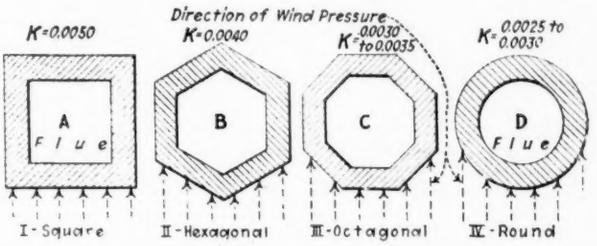
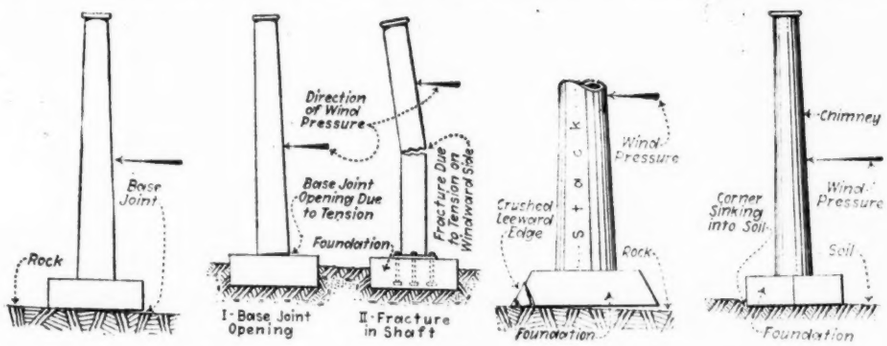


FIG. 5. VALUES OF THE WIND-PRESSURE CONSTANT K FOR CHIMNEYS OF DIFFERENT SECTIONS

Any chimney should have ample height for creating the needed draft pressure and for discharging the waste gases at an elevation that will remove all probability of damage to surrounding property and discomfort to occupants of the neighboring premises. Also, it should have ample flue area for passing effectively the gases generated from whatever fuel may be burned in the plant. Wind blowing against a chimney tends to overturn it as an integral unit, Fig. 1; break it at some plane of least resistance, Fig. 2; throw it out of perpendicular by causing an edge or corner of the foundation to fail, Fig. 3; or to sink into the supporting soil, Fig. 4. To safeguard against failure due to these tendencies, the chimney structure must be properly designed. The maximum wind pressure assumed as acting upon each square foot of projected area of one side of a square chimney is 50 lb. When the chimney is hexagonal, the pressure may be taken as about 40 lb. per sq. ft. of projected area, when octagonal as between 30 and 35, and when round as between 24 and 30 lb. per sq.ft. In the determination of these values it was assumed that the most violent wind never has a velocity exceeding 100 miles per hour. Such velocities have been recorded. Chimneys properly designed on the basis of the values stated will, experience has shown, stand.



FIGS. 1 TO 4. SHOW HOW CHIMNEYS MAY FAIL

Fig. 1—Entire structure tilting under wind pressure; unyielding soil beneath foundation. Fig. 2—Chimney joints opening on windward side due to wind pressure. Fig. 3—Chimney foundation may crush on the edge. Fig. 4—Leeward corner of foundation sinking under wind pressure.

Computation of the wind pressure acting on a chimney is based on the fact that the pressure upon a

*All rights reserved. This material constitutes a portion of the author's forthcoming book, "Steam Boilers."

surface, due to wind, is found to vary approximately as the square of the wind velocity. Thus the following formula is often used for determining the pressure imposed at different velocities:

$$P = kv^2 \qquad (1)$$

where P is the pressure due to wind upon a square foot of projected area, in pounds, k is a constant determined by the contour of the surface against which the wind is blowing, and v is the velocity of the wind in miles per hour. Values of k that may be safely used are given in Fig. 5, and are : For square chimneys, 0.005; hexagonal chimneys, 0.004; octagonal chimneys, 0.003 to 0.0035;

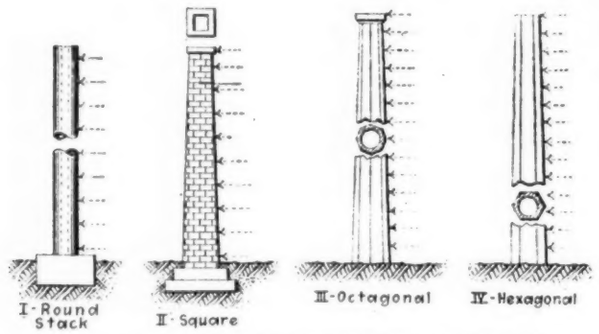


FIG. 6. FOUR EXAMPLES IN WIND PRESSURE AGAINST CHIMNEYS

and for round chimneys, 0.0025 to 0.003. All the values are high, as it has been shown that, excepting upon small surfaces, the value of k for a 100-mile-per-hour wind is only about 0.0032 (Gebhardt), which corresponds to a value of 32 lb. per sq.ft. for a wind velocity of 100 miles per hour.

A wind blowing 75 miles per hour impinges squarely against a steel stack, Fig. 6-I. What pressure per square foot of projected area, Fig. 5-IV, does the stack sustain? By formula $P = kv^2 = 0.0025 \times 75^2 = 14.06$ lb. per sq.ft. of projected area.

Most chimneys, particularly those of masonry, have a taper, or batter, because the wall thickness may be

TABLE I. SAFE STRESSES FOR THE VARIOUS MATERIALS USED IN CHIMNEY CONSTRUCTION

Material	Safe Stress — Pounds per Sq. In.	Safe Stress — Tons per Sq.Ft.
Brickwork in Portland cement	208–250	15–18
Brickwork in lime and cement	140–170	10–12
Brickwork in lime	110	8
Radial brick in lime and cement	278	20
Hollow tile	60–80	4.3–5.8
Firebrick { In fireclay	110	8
Firebrick { In air drying or fusing cement	170	12
Concrete	208–350	15–25
Steel, single-riveted	8,000	576
Steel, double-riveted	10,000	720
Steel, no rivets	15,000	1,080

decreased toward the top without decreasing materially the stability or strength of the structure. The tapered surface is always on the outside; hence the flue remains of constant diameter from bottom to top. When the stack is tapered, less material is needed. Furthermore, the total force of wind pressure is diminished, since the projected area of the upper portion is smaller than with a straight stack. The taper, Figs. 7 and 8, for the side of a chimney may be about $\frac{3}{4}$ or $\frac{1}{2}$ in. to the foot.

To compute the total wind pressure against the whole or any section of a tapered chimney, the following formula may be used:

$$F = \frac{L_{wb} + L_{wt}}{2} L_h P \qquad (2)$$

where F is total pressure due to wind, in pounds; L_{wb} is the width of the base of the chimney or of section thereof, in feet; L_{wt} is the width of the top of the chimney or section thereof, in feet; L_h is height of chimney or section thereof, in feet; and P is the assumed pressure due to wind, in pounds per square foot, as computed from formula (1). When the chimney is partly shielded by adjacent buildings, Fig. 9, only that portion need be considered which is actually exposed to the wind.

The total force of the wind may be assumed to act at the center of gravity of the projected exposed area of a chimney when determining the effect of the wind pressure upon the stability of or upon the stresses in the structure. This point at which the force of the wind may be assumed to act is called the center of wind pressure.

From Fig. 10 the total wind pressure, when the wind is exerting a pressure of 14 lb. per sq.ft., is $50 \times 10 \times 14 = 7{,}000$ lb., which may be considered as being applied as a single concentrated force F at the center of gravity G of the projected area.

To compute the height of the center of gravity of the projected area of a uniformly tapered chimney or of any section of it, use the formula,

$$L_{hc} = \frac{L_{wb} + 2L_{wt}}{L_{wb} + L_{wt}} \times \frac{L_h}{3} \qquad (3)$$

where L_{hc} is height, in feet, of the center of gravity of the projected area of the chimney or section of it, L_h is the total height of the chimney or section, in feet;

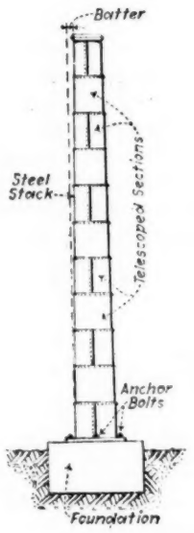


FIG. 7. STEEL CHIMNEY WITH UNIFORM BATTER

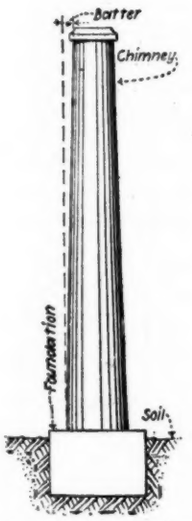


FIG. 8. MASONRY CHIMNEY WITH UNIFORM BATTER

L_{wb} is the width of the bottom of the chimney or section, in feet; and L_{wt} is the width of the top of the chimney or section, in feet.

What is the height of the center of wind pressure above the base of the wind-exposed section of a chimney, Fig. 9, that extends 72 ft. above the lowest buildings that surround it? Its top is 6 ft. across and the base of the section is 8 ft. Substituting in formula (3), the height of the center of gravity is

$$L_{hc} = \frac{8 + (2 \times 6)}{8 + 6} \times \frac{72}{3} = 34.3 \text{ feet.}$$

In practice it is often assumed that the center of wind pressure is at one-half the height of the chimney or

exposed section. Since the velocity, and hence the wind pressure, is greater at the top of the chimney than at the bottom, there is very little error in using this method. Such error as there may happen to be is on the safe side.

The center of gravity of the projected area of a wind-exposed chimney may be found conveniently by an experimental method, (Figs. 11 and 12). A scale drawing of the complete chimney structure is cut from card-

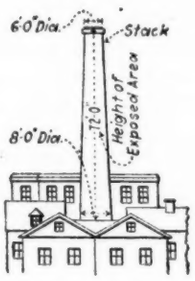


FIG. 9. CHIMNEY PARTIALLY SHIELDED FROM WIND

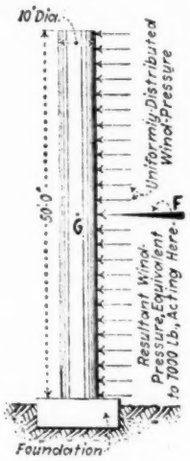


FIG. 10. WIND PRESSURE AT CENTER OF GRAVITY

board. The model thus made is pierced near opposite corners *a* and *b*. The model is first suspended from a pin passed through *a* (Fig. 11), and a plumb made of fine thread and suitable weight is likewise suspended from the same pin. The point *p* where the plumbline intersects the edge of the model is marked.

The model is then suspended from *b*, Fig. 12, and the point p_1 is similarly marked. The intersection *c* of the lines *ap* and *bp* locates the center of gravity of the area. If the model is perfectly free to oscillate about the points of suspension and is kept clear of any object that might retard its free motion, it will always come to

TABLE II. ALLOWABLE FOUNDATION PRESSURES ON SOILS*

Kind of Material	Safe Bearing Pressure — Tons per Sq.Ft. Min.	Max.	Lb. per Sq.In. Min.	Max.
Rock—the hardest—in thick layers in native bed	200	..	2 778	..
Rock, equal to the best ashlar masonry	25	30	347	416
Rock, equal to the best brick masonry	15	20	208	278
Rock, equal to poor brick masonry	5	10	69	139
Clay, in thick beds, always dry	6	8	83	111
Clay, in thick beds, moderately dry	4	6	56	83
Clay, soft	1	2	14	28
Gravel and coarse sand, well cemented	8	10	111	139
Sand, dry, compact and well cemented	4	6	56	83
Sand, clean, dry	2	4	28	56
Quicksand, alluvial soils, etc	0.5	1	7	14

* Use the minimum values rather than the maximum. The building laws of a locality may specify the safe values that must be assumed in that locality. If so such values should be used.

rest with its center of gravity precisely in the respective vertical lines (plumb lines) passing through the points of suspension.

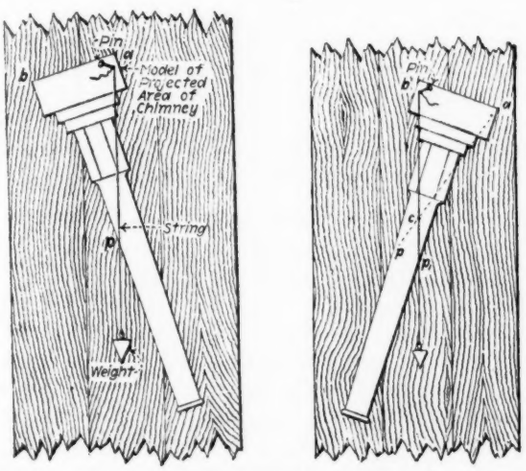
The sustaining ability of the soils on which chimney foundations bear must be considered in the design of any important structure. Practice and experiment have shown that there are certain safe pressures that should not be exceeded. After the weight of a proposed chimney and foundation has been computed, then the weight per square foot that it will impose on the supporting soil should be calculated. If the weight so imposed will be excessive, then the bearing area of the foundation must be made larger so that it will extend over more earth area and thereby decrease the weight imposed per square foot. Table II, from Baker's "Treatise on Masonry Construction," page 342, gives unit pressures which previous practice has shown to be safe.

Supporting Chimney Foundation on Piles

On uncertain soils the chimney foundation should be supported on piles, which are preferably driven to bedrock. A sandy, loose soil usually requires piles. Christie, in his "Chimney Design," page 34, states that piles should be of spruce with a diameter not less than 6 in. and driven by a drop hammer weighing one ton or more. The upper ends of the piles are then covered with a concrete footing and the foundation is built thereon. Wooden piles should not be closer together than 2½ to 3 feet.

Each pile may be expected to support a load of from 8 to 12 tons. Concrete piles may be designed to bear an average of about 30 tons each. (Marks' "Mechanical Engineers' Handbook," page 1,265). The concrete pile is indestructible and may be driven after molding and seasoning, or it may be molded in place in a mandrel that has been driven into the ground. If the pressure per square foot imposed by the dead weight of the stack and its foundation exceeds the values specified in Table II, the structure is likely to sink vertically into the supporting soil. This may result in straining and deranging the smoke connection between the boiler and chimney, Fig. 13, or in other damage.

When wind impinges on a stack, the latter acts like a lever arm and tends to force the leeward edge of the foundation into the soil, Fig. 14. It is assumed that the chimney, in shifting, rotates about some point *O*.



FIGS. 11 AND 12. EXPERIMENTAL METHOD OF FINDING CENTER OF GRAVITY

The location of this point need not necessarily be under the center of the foundation as is shown in the illustration. The formula for computing the maximum pressure, due to wind alone, under the extreme leeward edge of the supporting area of the foundation is

$$P_c = \frac{FL_h}{\left(\frac{I}{c}\right)} \qquad (4)$$

where P_c is the maximum compressive stress in pounds per square inch due to wind pressure; F is the force in

pounds due to wind considered as applied at the center of wind pressure; L_h is the height of center of wind pressure above the base in inches; and $\frac{I}{c}$ is the section modulus of the supporting area of the foundation. Values of $\frac{I}{c}$ for various areas may be found in handbooks.

A total wind pressure of 10,000 lb. is considered as applied at 50 ft. above the bottom of a round foundation. What will be the maximum compression due to the wind only, when the base is 16 ft. in diameter?

The value of $\frac{I}{c}$ for a circle is $0.1 \times d^3$ approximately, where d = diameter in inches. Then, substituting in formula (4), the maximum compression due to wind only is, $[10{,}000 \times (50 \times 12)] \div [0.1\ (16 \times 12)^3] = 8.48$ lb. per sq.in., or 0.61 ton per sq.ft., which is the pressure under the leeward edge. At every other point under the foundation the pressure is less than 0.61 ton per square foot. The total maximum unit pressure imposed upon the supporting earth is found by adding that due to dead weight and that due to wind.

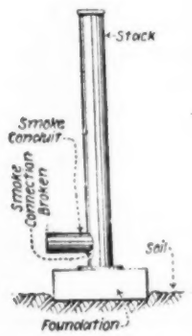


FIG. 13. SETTLING OF FOUNDATION INTO UNDERLYING SOIL

When designing a chimney, even if the computations show that the allowable stress upon the chimney material will not be exceeded and that the maximum stress on the supporting soil will be within the allowable limit, the structure should be checked for stability in accordance with rules given in the following: The stability of a chimney or of a portion of it above any plane —that is, its tendency to remain upright—may be determined by a graphical method by employing the principle of the composition of forces. This involves the finding of one force which is equivalent in direction and magnitude to all the forces under consideration.

Graphic Determination of Stability

It is desired to determine graphically the stability of a chimney. Refer to Fig. 15, in which the chimney is drawn to some certain scale, say 1 in. = 1 ft. Then the center of wind pressure is located at k. The distance kn is drawn so as to be proportional in length to the weight in pounds of the chimney or of the portion of it above any certain plane; for example, zy. The maximum wind pressure in pounds is indicated to scale by the length km. The parallelogram $knpmk$ is then completed and the diagonal kp drawn. The length of kp is then proportional to and gives the direction of the resultant force R. By extending the line of the resultant to the base of the portion of chimney under consideration, the position s on zy is located. If s falls within a certain distance x from the vertical axis q (as will be explained later), the chimney is safe, or "stable." If x is greater than the radius of the base, then the chimney has, when subjected to wind pressure, a tendency to turn over regardless of material. If s is near the edge of the chimney, the leeward side may be crushed and the windward side pulled apart in tension when the wind blows against the stack.

The distance from the axis of the chimney base to the point where the resultant cuts the base may be found from the proportion (Fig. 15).

$$\frac{x}{F} = \frac{L_{hc}}{W} \qquad (5)$$

from which is derived

$$x = F\,\frac{L_{hc}}{W} \qquad (6)$$

where x is the distance, in feet, from the vertical axis q of the section of the chimney to the point s where the resultant intersects the section; F is the force due to the wind pressure, above the plane zy, in pounds; L_{hc} is the distance from the section zy to the center of pressure k of the wind, in feet; and W is the weight of the chimney above the section zy in pounds.

The allowable maximum value for x, or the maximum distance from the axis of the base section of the chimney to the point where the resultant of the wind pressure and the weight of the chimney above the section passes, may be found mathematically, but the following rule is often used:

The resultant should pass not further from the axis of the chimney section than ½ the outer radius plus the inner radius. For other than round chimneys use the radii of the inscribed circles (Parsons in Steam Boilers).

This rule applies to any section of masonry stacks where no extension can be allowed in the outer edge of the wall.

For self-supporting chimneys supported on a square foundation, the resultant should pass through the lower surface of the foundation not farther from the axis than ⅓ the side of the foundation. Calculations for concrete stacks, in which tension is always allowable on the windward side, become complicated owing to the combined steel-and-concrete construction. Hence, expert reinforced-concrete stack designers should be consulted concerning concrete stack design.

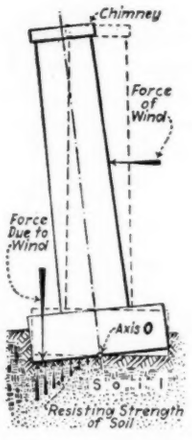


FIG. 14. WIND PRESSURE CONVERTED TO A DOWNWARD FORCE

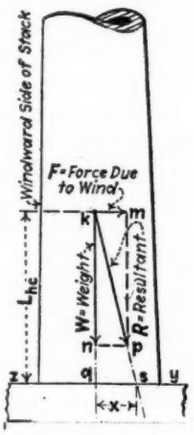


FIG. 15. SHOWING GRAPHICALLY A METHOD OF DETERMINING THE STABILITY

(This article is the first of three on chimneys, breechings and dampers. The next installment will deal with chimney construction features and methods of protection against lightning.)

Advocates the Transportation of Coal in Pipes

Present methods of transportation of fuel have become inadequate to the effective handling of the increasing mass of material which is necessitated by the demands of manufacture and the increase of the world's population. A process which destroys, as the system of railroad transportation destroys, nearly one-sixth of the material which it is transporting is manifestly uneconomical. The process also occupies an excessive proportion of human energy, in the crews of trains, and other railroad employees, whose energy can be better occupied upon the transportation of higher classes of material, better suited to bearing the cost. The cost of fuel is unduly increased by this system of hauling it upon wheels, involving the rehauling of empty cars back to the mines, the complexity and delay of car drilling, distribution and storage, with handling and rehandling of the fuel. The whole system is complex and is subject to disorganization by the least disturbance in labor, in the rail system, or by vicissitudes of weather. The invested value of the railroad, its cars, its locomotives and appurtenances is far too great for the class of material with which it deals.

Thus picturing the present wasteful and uneconomic method of handling coal Reginald P. Bolton, consulting engineer of New York, in a talk before the Society of Heating and Ventilating Engineers, proposed to solve the problem by the use of pipe lines such as are now used for the transportation of oil.

Consider that fifty thousand cars and three thousand locomotives are required to transport one hundred thousand tons of coal a day, a quantity that could be carried for hundreds of miles in four pipes twenty inches in diameter. The present cost of railroad transportation of fuel to the City of New York, said Mr. Bolton, is nearly three dollars a ton, while the expense of its transport in pipes would not exceed seventy-five cents.

How the Water-Flotation Idea Originated

The proposal to utilize the simple system of water flotation for the carriage of coal was originated by the late Wallace C. Andrews, who was a practical miner and a successful engineer, developed the successful distribution of steam in underground piping in New York, and became the president of the New York Steam Co., which is still in operation.

As coal has a specific gravity of one and eighth-tenths, six-tenths of its weight is borne by the water it displaces and the passage of a mixture of 50 per cent of coal with water in piping offers no greater, and in fact less, frictional resistance than that of water impregnated with mud or sand. Neither will the mixture thus traveling in a pipe have the same liability to freeze as would solid water, on account of the considerable air entrapped and carried in and with the coal.

It is hardly necessary to dilate upon these elementary features of the plan since it has been in successful operation for several years in an installation in England, where coal is passed with water through a pipe only eight inches in diameter and is lifted seven feet, at the rate of 240,000 tons a year, and at a total cost of twelve cents per ton. It is true this operation is carried on over a distance of less than half a mile, but greater distance involves no new elements except some known increase in internal pipe friction.

The pipe process is both simple in operation and inexpensive in installation. It involves the delivery of the coal at the mine into a hopper or chute, by which it is guided into the mouth of the pipe, where it is met by a jet of water of sufficient quantity and velocity to start the mixture upon its way. If the initial part of the system should be upon an up grade, the mixture of coal and water will be drawn into a centrifugal sludge pump, such as is now used upon dredging operations, and discharged into the pipe under sufficient pressure. This process would be repeated at intervals along the line, where the distance involves excess of friction, or where the grade may demand additional force.

A line of pipe could be installed inexpensively alongside an existing railroad right-of-way by which that property can earn additional income. The desirability of the pipe system is thus indicated to railroad companies, who can secure better returns upon their property, larger income, and a higher class of buiness on their existing rolling stock.

Separation of Coal and Water

The separation of the coal and water at the point of delivery is a simple process. The discharge of the mixture takes place over an inclined perforated screen, through which the water can find its way to a reservoir divided into several settling basins. In these the fine particles of coal held in suspension in the water are given time to settle, and after the cleared water is drawn off the sludge can be pumped out and either dried or formed into briquets.

Auxiliary pipe systems can easily be planned to distribute the fuel from the main point of discharge to other localities. The capacity of such pipe lines may be readily estimated upon a rate of flow, which, as in the case of water supplies, is determinable by consideration of the relative value of the size of the pipe or of the cost of power to pass the material through it.

As an illustration we may take the quantity of coal required for the warming of the homes and buildings of the metropolis, which is about seven millions of tons annually. By a suitable proportion of reserve fuel this quantity could be delivered by a daily flow of 19,000 tons, which, mixed with water in proportion of one-half of the total, would flow at the rate of 7 ft. a second through a pipe or pipes of 2½ sq.ft. combined area.

The water supply involved in this operation is not excessive, being only about 425 gallons per minute.

Capital Cost and Operating Expense

The capital involved in the construction of such an installation as that between Scranton and New York, a distance of approximately 165 miles, would be less than $20,000,000; and a liberally estimated cost of operation with all fixed charges places the expense at less than 75 cents per ton of coal transported.

It has been pointed out by Farley G. Clark, an engineer who has devoted much study to this subject, that the system of pipe transportation, if generally applied throughout the mining regions, would save the enormous amount of 75,000,000 tons now burned in the process of haulage.

He further demonstrated that the railroads are now occupying fully 35 per cent of their entire transporting capacity in the carriage of coal and return of empty cars, nearly all of which ought to be better and more profitably occupied in handling the higher class of freight.

Efficient Handling of Fuel Oil—VI

By ALLEN F. BREWER

THE requirements of furnace construction should be as follows: The arrangement of the heating surfaces should be such that the gas passages may be long and of relatively small cross-section. Thereby hot gas molecules will be enabled to strike the heating surfaces oftener and have to travel a less distance to do so, and with such an arrangement the heat transfer will be at its maximum. To accomplish this, it is easiest to increase the length of the gas travel, either by using a longer boiler or by baffling the existing gas passages in order to place the heating surfaces in series.

Then there should be the exposure of a sufficient amount of heating surface to the furnaces so that the full benefits of radiation may be obtained. There should also be combustion space of sufficient size to insure the complete burning of the fuel before the gases reach the colder boiler surfaces. The combustion space should increase in volume in the direction of flow of the hot, expanding gases. The capacity of an oil-burning furnace is practically limited by the furnace volume. The furnace must be lined with refractory brick, to radiate heat as completely as possible to the heating surfaces, and aid combustion to a maximum. Gas passages should be free from unnecessary turns, which would tend to reduce the draft. Such passages in the flues should be fitted with suitable dampers for control of draft and gas travel. All parts of the furnace must be accessible for easy cleaning and repair. The arrangement of construction should be such that the hot gases and water will always flow in opposite directions, and thereby the most complete transfer occurs, and unequal stresses because of temperature differences are diminished.

In burning fuel oil the construction of the furnace is of importance in that the gas passages may be long and of relatively small cross-section. This article deals with furnace construction details and furnace efficiency. The next article takes up the receiving and handling, usual tests and measurements of fuel oil.

Furnace Efficiency

The factor of furnace efficiency is practically determined by the size of the furnace and the type of the oil burner. The greatest efficiency is obtained by the most complete atomization of the fuel in a furnace of sufficient size for complete combustion. A furnace of too little volume will cause excessively rapid gas travel, due to rapid expansion and vaporization of the oil on leaving the burner tip, incomplete mixing with the air, passage of unconsumed fuel into the cooler parts of the boiler and flue, and possibly secondary combustion in it, due to excess carbon monoxide being present. Some heat may be recovered by secondary combustion, but this is counterbalanced by excess stress on the boiler tubes, drum, etc., which is most injurious.

With a burner that gives large oil particles, a correspondingly large furnace volume will be required, because more time will be necessary for the particles of oil to expand and vaporize. The expansion of such particles, in proportion to their size, will cause a relatively high furnace pressure, increase the rapidity of gas travel and tend to carry the larger oil particles into the gas passages in an unburned condition. The best burner is, therefore, the one that breaks up the oil into the finest particles, thus necessitating a furnace of but normal proportions.

Complete Combustion Depends on Three Factors

Complete combustion is a partner to furnace efficiency, and may be said to depend on three factors: The first is the extent of mixing the oil vapor with air, and the second is the time available for such mixing to be completed. It is perfectly evident that appreciable time is necessary for complete mixing, and if the furnace volume is too small, naturally, mixing will be incomplete. The third factor is the temperature in the furnace at the time of mixing. The higher the former the more rapid and complete will be the combustion.

Details of construction will be governed by the type of boiler installation. Every case may have its own peculiarities. In general, however, the "kinks" as to general construction, manner of placing brickwork, approximate sizes for various horsepowers, etc., will be very similar. The first concern is whether the furnace is to be a new installation constructed especially for oil burning, or a furnace converted from coal to oil. In the first case the fireman is little concerned. The mode of construction, size, etc., should interest him, but actually having to do with planning or building is out of his line. In a converted plant, however, he may be vitally concerned. In fact, if such conversion is of temporary nature he will probably have to do the actual work himself. Such a furnace is usually converted by simply laying a row of firebrick over the coal grates. The brickwork must never be placed hit-or-miss, but there should be proper spacing between certain of the bricks to insure the admission of air necessary for combustion. The various illustrations show how this should be done to obtain the best results in most cases. The amount of air space will depend on the draft available and the size of the boiler. All other joints should be made airtight with fireclay. The space underneath such brickwork serves as a preheating chamber for the air for combustion.

Burners may be installed either through the firedoors or the ashpit doors. The most general practice is to place them at the former, bricking up around them to prevent the escape of heat, and too much air from entering. It is well to leave out one brick, its space serving as a peep-hole and as an entry for the lighting torch. A certain amount of air will enter through this hole to serve as part of the air for combustion.

In such construction the ashpit door may be left intact, to be closed or opened as desired, in controlling the draft in conjunction with the damper.

The burners should be about three inches above the brick checkerwork, and except in a dutch-oven furnace the burner should extend about four inches into the furnace. When used in a dutch-oven furnace, an oil burner should extend into the furnace far enough to be in the same vertical plane with the front header or in front of the drum so as to avoid burning out the arch.

The bottom row of tubes should be protected by a layer of specially high refractory firebrick, particularly if a type of burner is used giving a conical flame or a flame that may impinge on these tubes and burn them out through careless handling or forcing. In a furnace used permanently for oil fuel no grate bars should be installed or left in if the furnace is converted from coal burning. The firebrick checkerwork may be built either on brick supports or resting on crossbars built into the furnace itself. The steel T-beam crossbar set lengthwise in the furnace is generally most satisfactory. (See Fig. 1 and accompanying illustrations.) It is generally assumed that the best results are gained from fuel oil by installing the burner so that the direction of the flame is toward an increasing volume of furnace. Thus, free expansion and complete mixing of the oil vapor with the air will be most likely to result. To carry out this idea in certain types of boilers the burner is frequently installed at the rear of the furnace, below the bridge wall.

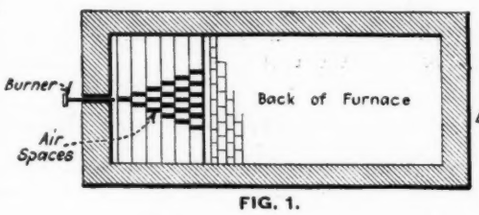


FIG. 1.

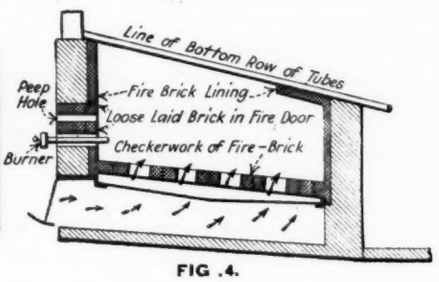


FIG. .4.

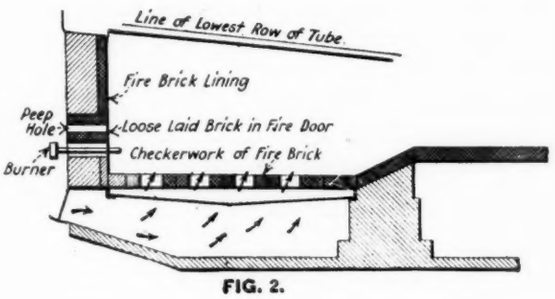


FIG. 2.

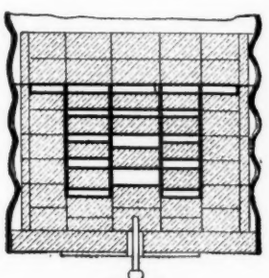


FIG. 5.

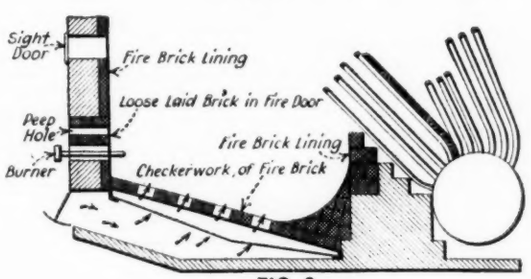


FIG. 3.

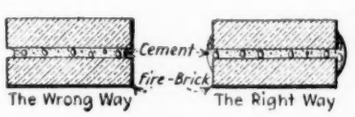


FIG. 6.

FIGS. 1 TO 6. SHOWING DESIGNS OF TYPICAL BAFFLING

Fig. 1—Plan of typical checkerwork. Fig. 2—Oil furnace for Heine types and return-tubular boilers. Fig. 3—Furnace for Stirling boiler. Fig. 4—Furnace for Babcock & Wilcox type of boiler. Fig. 5—Plan of checkerwork for Scotch boiler. Fig. 6—Method of laying brick.

In boilers where the bridge wall has been cut down or built low for fuel oil, such as return-tubular and some types of water-tube boilers, the bottom of the furnace is frequently built to curve gradually upward toward the rear. A rise of one-half inch per foot is good practice.

The entire surface of any oil-burning furnace should be as smooth as possible, to allow the rolling action of the oil flame to be unimpeded. Jointless firebrick, well glazed, will best accomplish this.

Furnace volume in an oil-fired boiler has the same significance that grate surface has in a coal-burning boiler. With water-tube boilers a unit volume of 60 to 80 cu.ft. per burner will generally give good combustion. The unit volume per burner will, of course, vary considerably, depending on the size and type of burner, draft to be carried and the possible overload that may be required. In calculating, the furnace volume must always include total volume of furnace and combustion chamber, in a water-tube boiler. In the Scotch or fire-tube boiler furnace volume is not so important a factor, because such boilers generally have but one burner per furnace, and the usual normal volume of the latter will be suitable for the average burner on the market. The primary function of the lining in a water-tube boiler furnace is to radiate heat and keep the furnace temperature at its highest and to aid combustion as much as possible. The water-tube boiler, on account of this lining is superior to the Scotch or fire-tube boiler, since furnace temperature remains more constant. Furnace lining should be of thoroughly tested, high-refractory firebrick capable of standing a continuous temperature in the neighborhood of 3,000 deg. F. It should be of accurately fitting shapes, preferably tongued and grooved to reduce the possibility of air leakage through the joints as much as possible. The number of joints should be as few as possible, to prolong the life of the lining. The life of a furnace lining is indefinite, depending on the manner of construction and the treatment it receives. From eight to ten months under continuous operation is good service.

In setting firebrick be sure to make proper allowance for expansion at the joints. Protect the edges of all bricks as much as possible; chipped bricks tend to go to pieces. Fig. 6 shows the manner of mortaring the joints. A good, high-refractory, plastic cement wash is valuable as an added protection after the bricks are laid; it will also prevent air leakage. Never apply such a wash until the furnace has been heated to dry the bricks and mortar. Then allow it to cool until the walls

can be comfortably touched and apply the cement coating; then heat slowly to insure even drying. Whenever a boiler is down for cleaning or repairs, inspect the brick lining, replace fallen bricks, patch up holes and chipped places, fill all cracks and renew the cement wash if necessary.

Assuming an average draft of one- to two-tenths of an inch of water, a checkerwork area of 2½ to 3 in. per rated horsepower will admit the required air to operate a boiler from its rated capacity up to about 50 per cent overload. The checkerwork must be of sufficient total area to admit the maximum excess of air required when operating under the heaviest overload, otherwise incomplete combustion and heavy smoke will result.

On the amount of air admitted practically depends the efficiency of an oil-burning furnace. A slight difference may mean a considerable loss of heat units, either by incomplete combustion of the fuel or by cooling of the heating surfaces.

Loss Up the Stack Greatest

The greatest loss in fuel is through heat loss up the stack. Further, this loss is divided into loss by excess air and poor heat transfer. Excess air over that necessary for perfect combustion performs no other function than to carry away heat that would otherwise have been used to generate steam.

Furnaces must be kept in good condition, with all joints in the brickwork tight, and no extra openings or seams in it. All such should be promptly filled in with a suitable refractory cement.

Don't allow carbon to accumulate in a furnace. It is an indication of low temperatures, and may be caused by excess cold air, worn burners, water in the oil or in the steam.

Don't allow the furnace to overload owing to scaled drum or tubes, sooted tubes or choked gas passages. Considerable heat losses will result.

Don't fail to examine and watch the brickwork and supports for melting, etc. It is caused by localization of the flame and "blowpipe" action. Continuation of such, particularly if the flame chances to strike the tubes, will cause the latter to burn out.

Don't allow the stack or uptake temperatures to exceed 500 to 550 deg. F. Considerable loss of heat and incomplete combustion will result. Regulate the damper more carefully.

Explanation of Figures

As shown in Fig. 1, the best arrangement of air checkerwork is in fan-shape, beginning about six to ten inches from the burner tip and extending back into the furnace about five feet. The ideal checkerwork is such that the flame from the burner will cover all the openings, that the air supply will be equal from all, and that no opening will be beyond the flame, since cold air would thus be admitted through such an opening to chill the heating surfaces. It must be remembered that it costs as much in fuel to heat air as it does to heat water.

Fig. 2 shows a typical checkerwork and furnace arrangement for a Heine or return-tubular boiler. The details are self-explanatory.

Fig. 3 shows a furnace section of a Stirling boiler. The angle of the checkerwork is shown at a maximum. For certain conditions, depending on the size of the combustion chamber, horsepower of the boiler, etc., this angle may be decreased, even placing the checkerwork almost on a horizontal line.

A typical furnace and air checkerwork for a Babcock & Wilcox boiler, with the burner installed at the front is shown by Fig. 4. The details are self-explanatory.

Fig. 5 shows a typical arrangement of air-spacing checkerwork in a Scotch (fire-tube) boiler furnace. The firebrick wall should be laid on a slope of about thirty degrees, supported on T-beams, the latter to be fixed at the front end at the firedoor dead-plate, the other end being set in a row of brickwork.

The right way and the wrong way to lay furnace firebrick are shown in Fig. 6. Never leave the brick edges exposed to the heat, as they will crack and chip. The right way to work the cement is to mold it over the edges in a bond, to serve as a protecting layer against the heat.

McNeill Soot Blower

The illustrations show a soot-blowing device that has recently been patented by William M. McNeill, 1328 Smeed St., Logansport, Ind.

The advantage claimed for the device is that the tube-blowing elements are, by means of an arrangement of

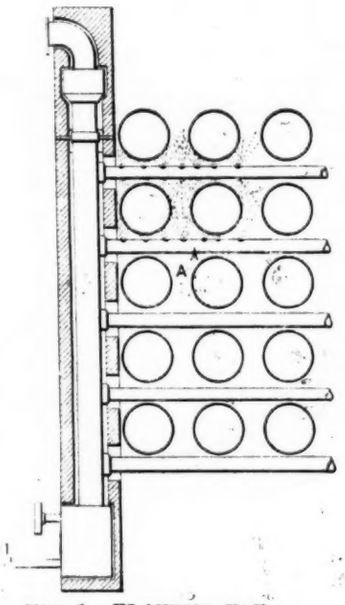


FIG. 1. BLOWING ELEMENTS IN CLEANING POSITION

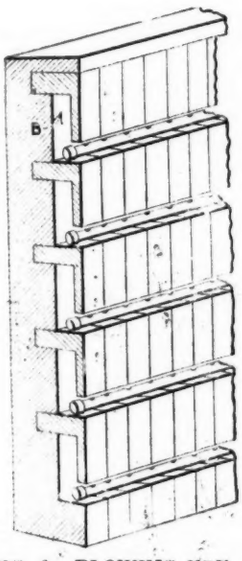


FIG. 2. BLOWING ELEMENTS IN PROTECTING RECESSES

gears, caused to swing out between the tubes, thus bringing the high-velocity steam or air jets into contact with the tube surfaces, as shown at *A*, Fig. 1. When the steam or air jets are directed on the heating surfaces at close range, they are claimed to be more effective than when the jets must be directed from the side of the boiler setting and across a wide bank of tubes, as in the latter case the velocity of the jets is spent before they reach the tubes on the opposite side of the setting.

The nozzle and pipes are protected from the hot furnace gases by special tiles, forming a recess in the furnace wall *B*, Fig. 2, in which the blowers rest except at such times as they are in the actual service of blowing the tubes.

It is claimed that this device is long past the experimental stage, that several sets have been in successful operation for more than four years and that they have never cost a cent for repairs although used under very severe conditions. As there will be corners that would not be reached in the travel of the blowing elements across the tube surfaces, this is cared for by nozzles in the end of the elements which reach these corners.

Operating with Non-Return Valves

The following is in substance the contents of a letter written by a representative of an insurance company requesting information regarding non-return valves, and the answer to the several questions by a manufacturer of such valves. It contains information that will be helpful to the operating man. The letter reads in part as follows:

We do not ourselves purchase non-return valves for boilers, but occasionally call the attention of our policyholders to the value of such valves in lessening the hazards of operating a boiler plant. You may be willing, therefore, to give us your advice on the practical difficulties that are encountered in maintaining such valves in operation.

Some years ago we suggested that non-return valves be placed on the boilers of several railway power stations. Valves of the triple-acting type were purchased and put in service. Considerable trouble was experienced in two power plants, and after trial was made also of a single-acting type the new valves were taken out of service and plain hand-operated valves were again used.

In the two stations where the non-return valves had not proved satisfactory the equipment consisted of five or six horizontal cross-compound reciprocating engines in varying sizes up to, perhaps, 2,000-kw. capacity. The boilers were all of the water-tube type with some variation in size, partly stoker- and partly hand-fired. The load showed considerable variation, as is often found in street-railway service, but not so extreme as would exist in a very small street-railway system.

It was found that the non-return valves vibrated considerably and, owing either to wear or to pounding, got into a condition such that the moving parts would stick and fail to operate. In some cases the valves could not be operated even by hand. May we ask the following questions:

1. Is it true that non-return valves, even of the best design, will vibrate constantly where the steam demand fluctuates constantly, or is such vibration merely an indication of defective design?

2. Does this vibration or valve-movement take place with each admission and cutoff of steam during each revolution of the engines or only with the slower variations of steam with the governor variations in response to load change? (It is asserted that non-return valves work satisfactorily on steam turbines, but not on reciprocating engines.)

3. Should there be any more or less tendency to vibration in triple-acting valves than in single-acting valves?

4. Can the trouble from vibration be eliminated by giving the valves a less sensitive setting?

5. Is this setting fixed when the valve is designed or can it be adjusted after installation for either triple- or single-acting type?

6. If the boilers that are operating on the same steam main vary in ability to respond quickly to steam demand should this cause vibration enough to wear out the valves quickly?

7. What are the principal causes of variable steam response from boilers?

8. For the usual power railway station where there are no long steam mains (such as are found in large mills), is the single-acting better than the triple-acting valve because of less complication on the boilers?

9. From the safety standpoint, what advantages do you consider that non-return valves have over hand-operated valves equipped with extension handles for floor operation?

10. Do you know of any cases where non-return valves have proved unsatisfactory, and if so, what were the causes of the failure?

11. Are non-return valves being generally used in new boiler installations where fluctuating loads will exist?

12. Which type of valve, triple or single, is being more generally used?

We shall appreciate any discussion of these questions that you may care to send us.

Abstracts of the manufacturer's reply are as follows:

We take pleasure in replying to your valued favor and answering your various questions, so far as we are able. Having had non-return valves in successful operation over twenty years we have had ample opportunity for studying their performance and perfecting their construction.

A non-return valve is subject to the most severe usage that can be placed on any valve, being attached directly on the boiler, where it first receives the highest temperature of steam, and being constantly in operation and without lubrication the wear is rapid unless properly designed and installed. Answering your questions numerically:

1. Good non-return valves, even of the best design, will quiver or vibrate under violent steam fluctuations, but quiet under modern fluctuation, while poorly designed valves will vibrate or pound heavily under the slightest fluctuations.

2. Vibration or valve movement takes place with each admission and cut off of steam to the engine, being accentuated by the increased speed of the engine, and this vibration is felt instantly back on the valve, irrespective of the length of steam pipe; on the same principle as if a door is suddenly closed at one end of a large, long room, instantly the windows or the doors at the other end will rattle in response.

3. There is, or should be, no more or less tendency to vibrate with triple-acting than with single-acting valves.

4. We are not sure as to what is implied by this question unless fitting the working parts of valve more loosely, in which case this would cause more vibration.

5. The "setting" or fitting of non-return valves is fixed when the valve is manufactured and cannot be adjusted after installation, but some makes of valves are automatically self-adjusted.

6. When a boiler operating on a main steam line with others is lagging, or fails to respond quickly to steam demand, the non-return valve is closed or nearly so, and upon demand for steam this boiler will, when able to respond, "cut in," and the valve will lift slightly and seat again instantly upon receipt of backlash. If, therefore, poorly constructed, this pounding of the seat soon ruins the valve; in some this pounding is eliminated entirely or reduced to a slight tapping, and in some instances is used by firemen as an indicator of a lazy boiler needing attention and coaling when hand-fired.

7. The principal cause of variable steam response from boilers or fluctuation in the main steam pipe is the sharp cutoff of engines or pumps, causing a backlash.

8. For the usual railway power station with short main steam pipe, especially when new or modern construction, the single-acting valve is to be recommended instead of the triple-acting valve.

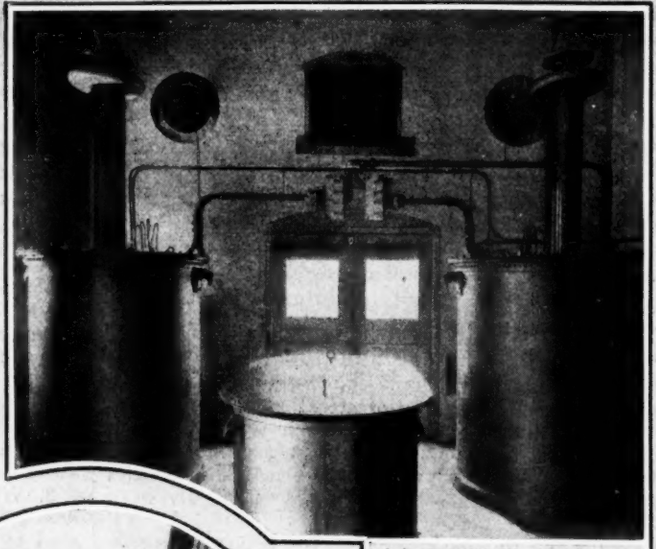
9. To use plain hand-operated stop valves on boilers, even with extension handles to the floor, would be going backward, as from a safety viewpoint an automatic valve is instantaneous, while hand-operated valves in case of emergency might be unapproachable and great damage occur.

10. Poor non-return valves have undoubtedly proved unsatisfactory, and thereby have caused non-return valves in general to be brought in bad repute, but the remedy has been to install good valves in their place, and this we have done in a number of cases.

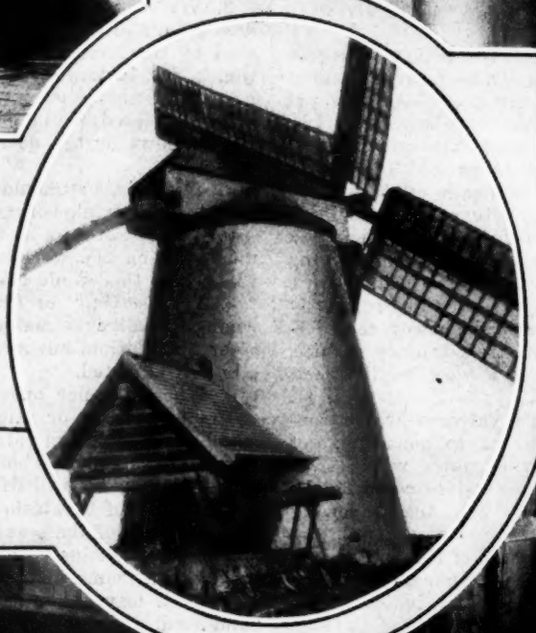
11. Non-return valves are now being universally used in modern power plants, irrespective of fluctuating load conditions.

12. The single-acting or plain stop-check valve is the type most likely to be considered and used in mills and plants having old established and long steam lines, where a bursting of the same might cause considerable damage to property or loss of life.

The old battleship Kearsage is being converted into what is expected to be the largest capacity self-propelled crane in the world, in view of its great reach and capacity of 250 tons.

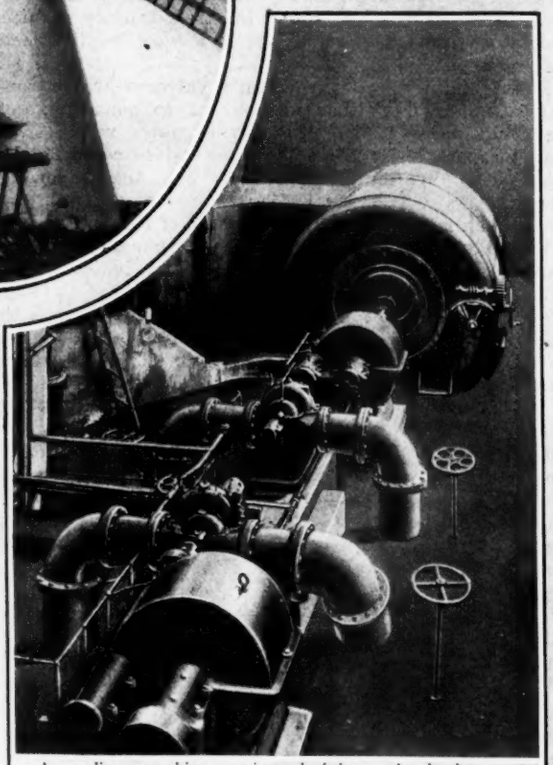


A feature of the New Purdue University testing laboratory — two 300,000-volt, 135 kva. oil cooled transformers, which may be connected in series to give 600,000 volts.



How power is obtained on the Island of Barbados. This is one of ninety similar "power plants" used to drive sugar mills.

Tubes taken from a 25,000 sq. ft. condenser at the 59th St. Powerhouse of the Interborough Rapid Transit Co., N. Y., one of the stations which supply power to the subways of New York City.



A speeding-up turbine gear instead of the usual reduction gear. Two 200 r.p.m., low-head, water-turbines driving two DeLaval centrifugal pumps at 1670 r.p.m., installed at Cornwall, Ontario. Both pumps and one turbine are shown here.

What Superpower Means*

BY HENRY FLOOD, JR.†

THE superpower idea is not new. It is only the expansion of present central-station practice greater in magnitude but not more complex in structure. It is the replacement of small-scale by quantity production.

While great progress has been made in reducing power costs and in conserving fuel by the central-station systems of this country, there is still much that can and must be done along these lines. The recent war made many thinking men realize that notwithstanding the improvements that have come into operation during the last ten years, there is still going on in this country a vast waste both of fuel and money in the production of power, and some of these men who had a greater visionary power further realized that these very wastes would become a tremendous handicap to us in the competition for the world's markets which has followed after the war. These wastes have been recognized and have been frequently discussed, but to William S. Murray the credit must be given for bringing the country from out of the period of discussion into that of positive action. The North Atlantic seaboard was the region selected for the first Superpower Survey, and the reason for such a selection is not hard to find. This section of the country, which is known popularly as the Superpower Region, embraces the territory along the North Atlantic seaboard from about Portsmouth, New Hampshire, to Washington, D. C., and extends inland on an average about 150 miles. Geographically, it is a very small portion of the country, as it contains only about 2 per cent of the total land area. From the viewpoint of population it is important, as about 22 per cent of our inhabitants live within its borders. According to the recent census 75 per cent of the people in those states of which the Superpower Region is a part, live in cities and towns, while for the rest of the country only about 41 per cent are city dwellers. Its most important relation to the country's needs, however, is its industrial activity, as nearly 40 per cent of the total value of manufactured products come from this region, and 35 per cent of the country's power is generated there.

This industrial supremacy can easily be visualized from the fact that one out of every 8 persons living therein is an industrial worker, while for the remainder of the country there is only one out of every 25 persons so employed. New England is even more intensely developed from the industrial viewpoint, as one out of every 6.4 persons is a wage earner in its factories.[1]

Superpower is a word that rolls easily off the tongue and is often used by those who have a very hazy understanding of the term. This article explains the whole situation. It is a clear-cut, understandable analysis of the need for a superpower system, the present status of the idea and its future possibilities, and was written by a man whose identification with the movement entitles him to speak with authority and certainty on the subject.

Another measure of the industrial activity of the Superpower Region is shown by the output of manufactured products, which was $314 per capita in 1904 and $390 per capita in 1914, while the rest of the United States produced manufactured articles to the value of only $113 per capita in 1904 and only $190 per capita in 1914.

This intense industrial development results in a large demand for power to operate the industries and to provide transportation for raw materials into the region and for the finished products to the peoples living without the region, and hence it was logical to select this district as the one in which could best be shown the merits of a regional power system.

The history of our power development has been truly remarkable when compared with that of other countries. It has grown from a period when we had practically nothing but small isolated plants to the present time, when we have large central station companies serving extensive areas and populations. However, today these companies are for the most part segregated and have either no connection with their neighbors or only very light connections where the interchange of power is principally for breakdown purposes. It is very seldom that we find these connections between the central-station companies such that power may be interchanged with a view toward a more economical operation of the participating companies.

Superpower goes a step in advance. It provides a regional system through which all the large load centers within its boundaries will be linked together by means of heavy trunk transmission lines capable of carrying sufficient power so that each power plant can be operated in the manner necessary to get the greatest resultant economy to the entire region.

It provides for the construction of large base-load steam-electric plants at tidewater, on inland rivers, or in the coal-mining territory, as conditions may warrant.

It makes possible the construction of hydro-electric developments at potential water-power sites, the development of which is not now advisable with the conditions existing on our present power systems.

Superpower does not consider the abandonment of present central-station systems. They are the nucleus about which a superpower system would be built up. While plants that are older and more expensive to operate will have to be abandoned gradually, the larger and more efficient ones will become an integral part of a regional system for furnishing power.

Superpower visualized is but a large power reservoir into which will feed the output of the more efficient existing plants, the proposed new base-load steam-

*From a paper delivered before the Worcester Section of the A. I. E. E. on Feb. 2.
†Engineer-Secretary, Superpower Survey.
[1]Information derived from United States census reports.

electric stations, and the hydro-electric stations, and from which the power to supply the industrial, the railroad and domestic requirements of the various load centers will be tapped where and when needed.

As great as are the power requirements of the region today, they are small compared with those of tomorrow. The unassociated total power requirements have increased from about 15,000,000,000 kw.-hr. in 1910 to about 27,000,000,000 kw.-hr. in 1920, with a corresponding increase in machine capacity from 8,600,000 kw. to approximately 14,800,000 kilowatts.

It is estimated that the power growth for the next decade will increase the total energy requirement to

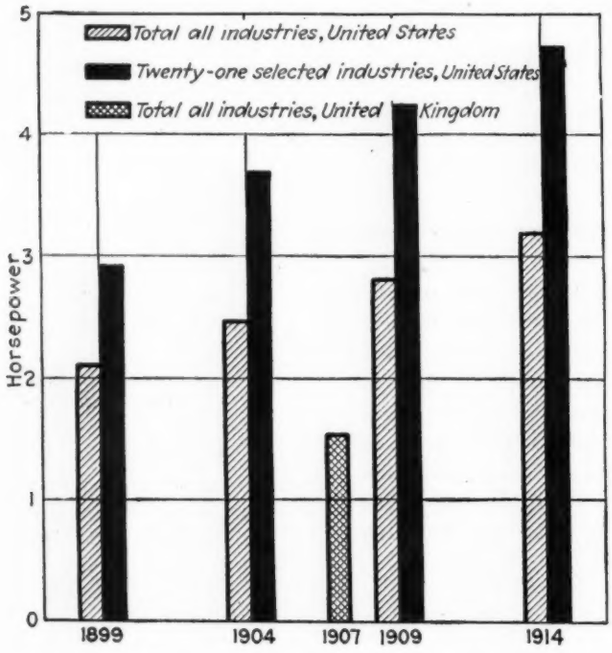


FIG. 1. HORSEPOWER USED PER WAGE EARNER

The twenty-one selected industries shown here are fairly representative of the Superpower Region, which is more comparable to England than the country as a whole.

about 50,000,000,000 kw.-hr., and assuming the superpower to be in operation, about 18,700,000 kw. of machine capacity will be required to satisfy this load.

Electric public utilities furnished in 1920 about 12,000,000,000 kw.-hr. with a machine capacity of 4,000,000 kw., and it is predicated that by superpower operation the power to be furnished from central supply sources will grow to about 36,000,000,000 kw.-hr. by 1930 and will require a machine capacity in the neighborhood of 9,000,000 kilowatts.

These estimates, which are conservative, call for 5,000,000 kw. additional power-plant capacity in the central supply systems during the next ten years, an increase of 125 per cent over that now in existence.

In making these preliminary estimates consideration has been given to the fact that some of the manufacturing industry today receives its energy directly by water power, and further that it will undoubtedly be found unprofitable to take over to a superpower system certain isolated plants in manufacturing industries which have use for large amounts of steam for process and heating work. Furthermore, it is realized that only a certain amount of the track mileage of the heavy-traction railroads will have traffic sufficient to justify electrification, so that only those portions of the railroads have been included which can profitably be electrified.

In the manufacturing industry the estimated power requirement of 1920 has been placed at 12,400,000,000 kw.-hr., and it is estimated that the central-station systems supplied about 2,750,000,000 kw.-hr. of this total requirement. By 1930 it is conservatively estimated that the total power load of manufacturing industry will increase to about 19,000,000,000 kw.-hr., and that superpower can economically furnish at least 10,000,000,000 kw.-hr., or slightly over 50 per cent of the total. While making these load estimates it has been realized that there are certain possibilities of the future, such as the extensive use of electricity for furnace work and heating. Just what growth will be contributed by any such developments is purely conjectural; accordingly it has not been considered.

One of the prime effects of a regional system would be the better utilization of our nation's fuel supply. Few persons realize that of our total coal resources only about 16 per cent lie in the Eastern province; that is, within easy freight-transportation distance of our North Atlantic seaboard. Furthermore, probably still fewer appreciate that out of the total coal mined

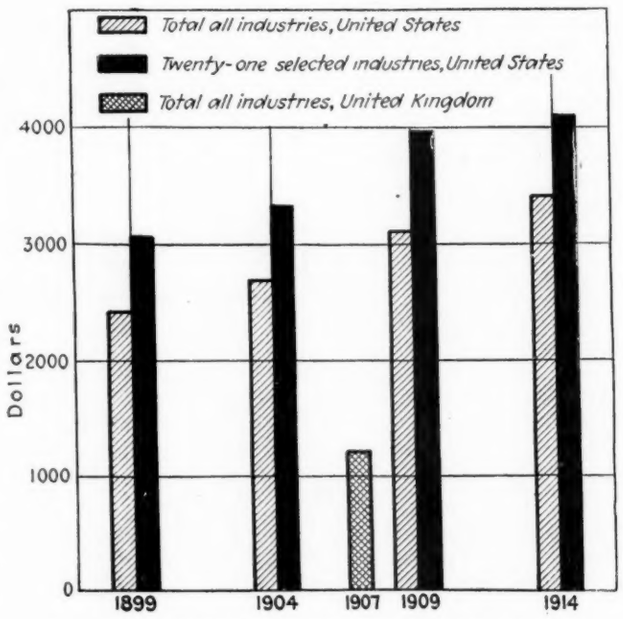


FIG. 2. VALUE OF PRODUCTS PER WAGE EARNER

The comparison with England in this chart is even more striking than in Fig. 1.

to date about 75 per cent has been withdrawn from the coal fields lying within this province.[2]

While considering that these particular coal fields, even when supplying the greater part of the country's coal requirements, still have many years' existence, we cannot ignore the fact that the comparatively rapid depletion of this field is fast working a hardship on this section of the country through the agency of advancing coal prices, brought about by the exhaustion of the higher-grade and more cheaply mined coal seams within this particular region. That coal will be very much cheaper for extended periods than it is at the present

[2]Data from United States Geological Survey, Professional Paper 100-A.

time seems hardly likely in view of these conditions; in fact, all the evidence points to just the reverse.

The coal user seldom decides his policy of coal utilization from the viewpoint of national conservation, but rather upon what the cost of power will be to himself. The relatively higher coal prices that have existed for the last four years have had their effect through making it essential for the coal user to conserve his coal in order to keep his costs down.

From the studies made to date by the Superpower Survey it is indicated that the central-station systems within the region paid an average of about $5.40 per net ton for bituminous coal delivered. The engineers of the survey have made a careful study as to what the probable average cost of bituminous coal will be during the ten-year period from 1920 to 1930, and as a result of their consultation with the recognized authorities on the subject of bituminous coal they have come to the conclusion that the average cost of coal at the mine for that period will be higher than that which was in force in 1919, and that the freight will probably not vary greatly from the present rates, which are 40 per cent in excess of those paid in 1919.

Estimated Results of Superpower

Had superpower been in operation in 1920 a saving of about 30,000,000 tons of coal having a value of about $162,000,000 could have been effected through its economies over the present performance of central stations, steam locomotives and isolated manufacturing plants, and by 1930 the superpower system should effect a saving of 53,000,000 tons per annum, with a value of $286,200,000 when compared with present practice.

Despite the estimated savings given here the load growth of this particular region is such that by 1930 at least 14 per cent more coal than is now being used for power-production purposes will be required to take care of a superpower system and the other power-production facilities that would be left in the region. The argument has often been advanced that a superpower system would have the very serious effect upon the railroads of making idle the vast investment in equipment through removal of coal haulage from their lines, but these figures show that this fear is absolutely unwarranted.

With regard to coal superpower offers also another great advantage. It will be the greatest stabilizer of the coal industry through large coal-storage areas at each of its large base plants, thus placing a more uniform demand for coal upon the mining sections. Those who are familiar with some of the elements of the cost of coal mining will appreciate the importance to the coal-mining industry of any such agency.

Influence of the War

The war brought about a number of changes in our power practice. The cost of power-producing equipment went up and deliveries were long delayed. The price of coal rose rapidly, and not only was it scarce but often great annoyance was encountered in obtaining it. The country was calling for production and then more production, and as a result of these contributory causes the manufacturer turned to the central station for his power requirements as never before. He accepted central-station power and devoted the money he would have spent in building and operating his own power plants to the actual production of these products.

One further effect of the war has been that our industrial production facilities have been increased so that their output cannot be absorbed by our home markets if all of these facilities are to be kept employed. The ratio of our exports of manufactured products to raw materials was much larger for 1920 than in any pre-war year, and this is as it should be, for the exports of manufactured articles represent the employment of more of our labor at home. However, it brings us face to face with competition against the cheap labor of the rest of the world, and to maintain our position as leaders in the world's markets it is necessary that we make our more expensive man power cheaper than that of the balance of the world through the agency of added machine power.

In the decade between 1904 and 1914 our machine power per industrial worker increased from 2.5 hp. to 3.2 hp., and at the present time it is estimated to be over 3.5 hp. In 1907 Great Britain used 1.55 hp. per wage earner. During the same decade the value of products per wage earner in this country increased from $2,700 per annum to $3,430 per annum, while Great Britain in 1907 produced manufactured products to the value of only $1,220 per annum per industrial worker. The relation between machine power and the output per wage earner is thus strikingly brought out, and on its face shows one of the reasons for our successful competition with the cheap labor of Europe.

The Superpower Region is comparable to England inasmuch as both may be considered finishing shops. The Superpower Region contains 355 classified types of industries, of which 36 use 77½ per cent of the total power and 76 per cent of the total coal. Complete records are available for only 21 of the 36 industries, but these records disclose the fact that in 1904 these 21 industries used 3.7 hp. per wage earner, and in 1914, 4.7 hp. per wage earner. The corresponding value of products per annum per wage earner was $3,340 in 1904, and $4,135 in 1914.[3]

What Other Nations Are Doing

The foreign nations that are our competitors have recognized that the weakness in their industrial system is the lack of adequate machine-power facilities, and they are feverishly working to correct this situation.

England in 1918 undertook a study of its power conditions, and as a result of the reports made by the Committee on Electricity to the Board of Trade there has been set up a definite power policy under governmental supervision, by means of which she hopes to bring her power facilities to a parity with our own. The British Isles have been divided into thirteen natural power districts under the authority of a Board of Electricity Commissioners which has the power to direct the character and magnitude of all future electrical generating or transmission facilities, whether they be in central supply service or in isolated manufacturing plants. It is interesting to note that in the report of the Committee on Electricity to the Board of Trade it is stated: "Investigations have shown that in the United States of America the amount of power used in industries, expressed in terms of the number of operatives employed, is greater than in this country. In practically all our industries the horsepower per operative could be increased with advantage both to capital and to labor, as is shown by the results obtained

[3]Derived from United States Census Bureau reports.

in the United States of America, where both the net horsepower per operative employed and the standard rates of wages are higher."

Switzerland is taking active steps to make available more power for her industries, while Holland, Italy and France are doing likewise.

In Germany an extensive system, one, in fact, comparable to our proposed superpower system, is actually being constructed and placed in operation. The German plan provides for very large plants located at the coal mines and calls for the conversion of as much of the coal as is possible directly into electrical energy. It further provides for the organization of the different industries, such as the textiles, the chemical industries and others, into associations which will negotiate their power requirements and prorate the use of the various individual plants. The plan is one of copartnership between private enterprise and the government and takes into consideration giving capital an incentive for good management and for the rapid development of the coal mines to provide additional electrical energy. The central idea back of the scheme is to provide adequate and cheap power for the manufacture of goods intended for export.

What the Situation Demands

If we are to compete successfully with these European countries having cheap labor, who have in addition recognized the value of mechanical power, we dare not stop at any figure of power utilization in our factories of 3½ hp. per wage earner, but we must keep the differential between the machine power used in this country and that abroad at least equal to what it is today.

Superpower recognizes the fact that if our industry is to compete in the world's markets, power in unlimited quantity must be made available to industry; it recognizes that the quality of service is of paramount importance, and therefore in laying out the tentative system one of substantially heavier construction than has ever been used in this country is being considered. It takes into consideration the fact that industrial success is dependent to a large degree upon transportation, and it provides the means for the increase of transportation to satisfy industrial demands through the electrification of those portions of our heavy-traction railroad systems where the traffic density is such that electrification will either create a saving in the cost of operation or create additional traffic capacity through its ability to handle the traffic more rapidly.

How Superpower Will Save

The regional power system advocated by Mr. Murray is basically sound. That large savings will accrue from it is evidenced by the savings already effected through the extension of our central-station structure.

These savings of both money and fuel accrue from a number of causes. The regional system permits advantage to be taken of the diversity between the peak loads of the several districts and allows the use of joint reserve equipment in place of the segregated reserves of much greater magnitude now required.

Through industry and the railroads the saving is brought about by quantity production displacing small-scale production, and further by the ability of the regional system to take over their loads having an inherent load factor of not over 15 per cent, and so raise the regional system's load factor to 50 per cent.

The pooling of the large part of the power in the region has a beneficial effect on the cost of both steam-electric and hydro-electric power, as it permits the use of highly efficient base-load steam-electric plants operating at very high capacity factors, a condition that cannot be obtained except on the very largest of our present electric utility systems, together with the use of hydro-electric power for carrying peak loads.

As is well known, the rivers in the eastern part of the United States are subject to great variation in flow, and few of them are adapted to the operation of base-load power. Their development has heretofore been retarded by the very fact that no such power reservoir as that proposed in the superpower system has been available for their output, and the creation of such a reservoir will bring the opportunity for the development of these potential water powers.

In conducting its study the Superpower Survey has recognized as a fundamental principle that the franchise rights and investments of the existing electric public utilities must be respected and safeguarded. The function of a superpower system is to furnish the interlinking system only and to provide such generating stations, either steam-electric or hydro-electric, as can be justified from the point of view of a lower production cost only. Its operations must cease where those of the electric public utilities begin; that is, at the buses of the principal load centers.

Final Considerations

It is evident, particularly in the earlier stages of a superpower development, that it will be more economical for such a system to receive energy from the newer and more efficient existing central-station plants where such energy can be obtained above their own requirements, than it would be for it to construct its own plants. On the other hand, it is just as evident that certain of the older and less-efficient plants must be abandoned in order to reach the lowest cost of power and the greatest fuel conservation, but the replacement of these plants should not take place until the margin of saving between superpower, and that of the abandoned plant is sufficient to allow for the latter's gradual amortization over a period of years out of a portion of the savings so effected. It is only by such a method of the gradual retirement of capital that the interests of present investors can be protected.

In this connection, and of prime importance, will be the presentation in the report of a chronology in the order of their requirement of the first and following locations of superpower stations and their attendant transmission lines. Data already analyzed indicate the immediate size and location of stations, and from this start, which will be financially self-supporting, will be developed the extension of the system into its whole.

The principles that have governed the expansion of our city and territorial power systems are entirely applicable, only in a higher degree of magnitude, to the regional system for the Superpower Zone. The size of power-producing units and attainable voltages are such that it is no longer required that these units be placed side by side, joined by a common bus under one roof, but they may be made to come into intimate relation with one another although separated 300 miles; and vast as the superpower system may seem, such a visualization of it will serve both to simplfy its aspect as well as to show that a regional situation must be met by a regional plant.

Low-Voltage Step-Down Transformer

By H. H. PARKER

ONE or more small, low-voltage transformers are useful devices to have around the power plant or factory where alternating current is available. While many varieties of the small bell-ringing type are on the market, the one to be described, details of which are shown in Fig. 1, has a larger capacity—100 watts for continuous operation or considerably more for intermittent work. Of course, when used on intermittent service, temperatures within safe heating limits will determine the capacity. The transformer is intended to operate from a 110- or 220-volt single-phase 60-cycle lighting circuit, furnishing a secondary voltage of 3, 6 or 12 volts for ringing bells or operating other signals, lighting low-voltage lamps (Fig. 5), for gage-glass lamps, trouble hunting and other uses. Besides this the 110-volt transformer may be connected up as an auto-transformer and furnish 220 volts for testing purposes (Fig. 3), or 55 volts (Fig. 4) should occasion require. Often there is danger in exploring boiler and tank interiors with an electric lamp, even with a voltage of 110, but if a small transformer of this type is brought near the manhole and then a flexible cord and low-voltage lamp attached to the secondary terminals and carried inside, even under extreme conditions no danger exists from the 6-volt circuit. The amperage supplied is enough to light any size battery bulb, so that plenty of light can be had. With primary and secondaries in parallel the secondary low-voltage current will fuse a $\frac{1}{16}$-in. iron rod.

For continuous operation the primary coils are supposed to be connected in series, but for intermittent work a parallel connection may be used as long as the coils do not heat unduly. The following table gives the different secondary voltages obtained; the secondary coils will operate continually either in series or parallel.

Primary Turns In Series	Coil Connections	Secondary Turns In Series	Coil Connections	Secondary Volts
1000	Series	56	Series	6
1000	Series	28	Parallel	3
500	Parallel	56	Series	12
500	Parallel	28	Parallel	6

The construction of a small transformer is simple and is clearly indicated in Fig. 1. First the core sheets are secured; stove sheet iron will probably be the easiest to obtain, in about No. 24 gage, though thinner material, such as the sheet iron used in making cans, would be preferable. The best material is regular transformer iron or silicon steel, but unless some can be secured from an old burned-out transformer or choke coil it will be difficult to obtain in small quantities. Two sets of sheets are cut. One has dimensions 1 x $3\frac{3}{4}$ in., and the other, 1 x $2\frac{3}{4}$ in. Enough of these sheets must be provided to make a core one inch thick when pressed together, as in Fig. 2. The long sheets, forming the legs upon which the coils are wound, are assembled first in two piles with alternate sheets overlapping one inch, making the legs $4\frac{3}{4}$ in. long. After the coils are wound the shorter, or yoke, pieces will be fitted across the projecting ends of the legs. Two sets of heads are made for the coils, as shown at *B*, Fig. 1, of quarter-inch fiber, one pair having grooves for the secondary terminal strips. The sheets are tightly pressed together and the heads forced on, leaving an inch projecting, as in *E* and *F*. Each core is then tightly bound with friction tape and wrapped with two layers of empire cloth or paper. If a lathe is at hand the winding is best done on it, a revolution counter being driven into a wood plug at the

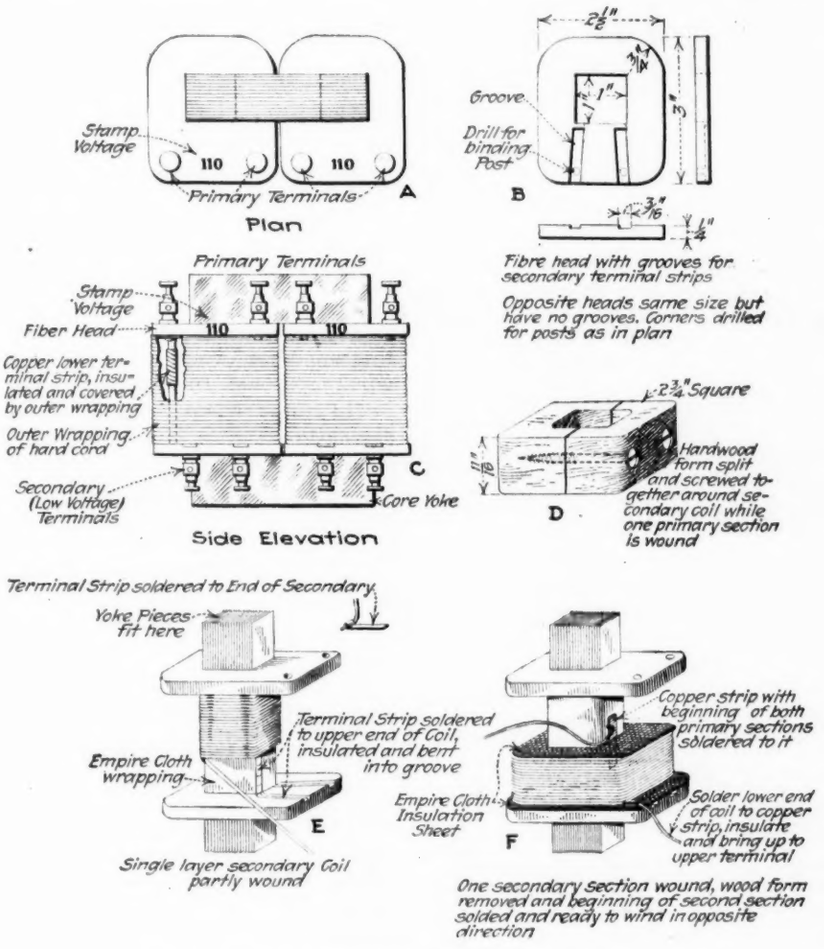

Stamp Voltage
110
110
Primary Terminals
A
Plan
Groove
Drill for binding Post
1"
3"
B
Fibre head with grooves for secondary terminal strips
Opposite heads same size but have no grooves. Corners drilled for posts as in plan
Primary Terminals
Stamp Voltage
Fiber Head
Copper lower terminal strip, insulated and covered by outer wrapping
Outer Wrapping of hard cord
Secondary (Low Voltage) Terminals
Core Yoke
C
Side Elevation
2¾" Square
Hardwood form split and screwed together around secondary coil while one primary section is wound
D
Terminal Strip soldered to End of Secondary
Yoke Pieces fit here
Empire Cloth wrapping
Terminal Strip soldered to upper end of Coil, insulated and bent into groove
E
Single layer secondary Coil partly wound
Copper strip with beginning of both primary sections soldered to it
Empire Cloth Insulation Sheet
Solder lower end of coil to copper strip, insulate and bring up to upper terminal
F
One secondary section wound, wood form removed and beginning of second section solded and ready to wind in opposite direction

FIG. 1. DETAILS OF TRANSFORMER CONSTRUCTION

rear end of the spindle to keep count of the number of turns. Two blocks of hardwood an inch thick, each with a hole one inch square, are made, one being screwed to the faceplate and one having a metal strip centered for the tailstock; the core is held between these blocks. A strip of copper is run the full length of the winding space, one end bent into one of the grooves in the fiber head and the other soldered to the end of the coil after it is

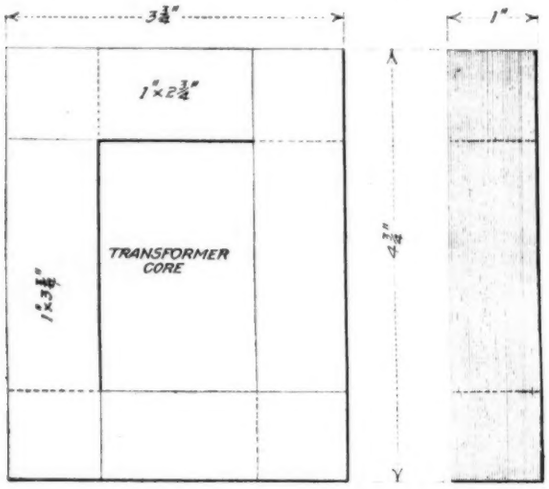


FIG. 2. TRANSFORMER CORE

wound. The strip is insulated with a paper wrapping. A shorter strip is bent around the beginning of the secondary wire, which is No. 10 double-cotton covered copper, soldered to it and embedded in the other groove. Then 28 turns are wound in a single layer and the end is soldered to the long terminal strip and cut off. A sheet of empire cloth, split, is placed over the heads to cover the grooves and insulate the strips from the primary winding, and the layer of wire is wrapped with three layers of insulating cloth. These details are shown at *E* and *F*, Fig. 1.

The primary, or high-voltage, winding is wound in two sections, in opposite directions, the beginning end of each section being soldered to a copper strip, common to both, glued to the center of the winding space (see *F*, Fig. 1). To wind the first section half the space

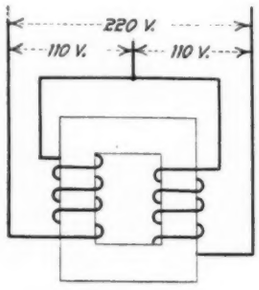


FIG. 3. AUTO-TRANSFORMER, 110 TO 220 VOLTS

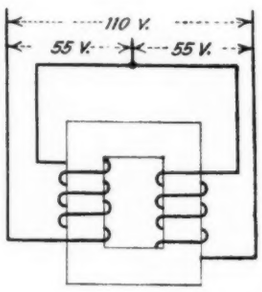


FIG. 4. AUTO-TRANSFORMER, 55 TO 110 VOLTS

is filled with a split hardwood block (see *D*) screwed together over the secondary coil and its insulation. Solder the beginning of the coil to the central strip and wind on, direction immaterial, 250 turns of No. 20 double-cotton covered copper wire in even layers with a strip of insulating paper between every two layers. There will be 10 layers of 25 turns each. Then remove the wood filling block, slip on two insulating sheets of empire cloth with alternating joints and wind on the remaining section of 250 turns, but wind in the opposite direction from the first, or else reverse the coil in the lathe and turn the same as at first. Attach the near terminal to one of the primary binding posts, wind on three layers of empire cloth, solder a long

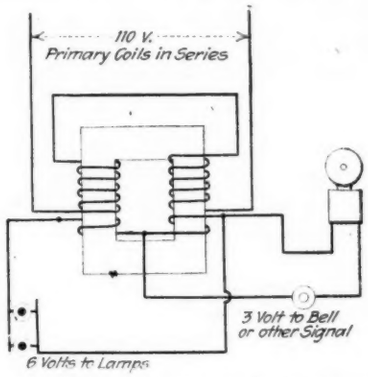


FIG. 5. SECONDARY COILS IN SERIES; ONE COIL TO BELL, TWO COILS TO LAMPS

copper strip to the other wire terminal, wrap it in paper and bring up to the second binding post. Then wind on a close layer of heavy hard cord to protect the windings, give it a couple of coats of shellac and bake well to dry out all moisture. Complete the second set of coils the same way. This will give, on each leg, a primary winding of 500 turns and a secondary of 28; 1,000 being the total number of primary turns required. If the line voltage is 220 use No. 23 wire and twice the number of turns, 1,000 on each leg; the secondary winding would remain the same.

The coils are now set side by side and the yoke sheets driven in place, alternately, between the projecting core sheets; a binding of tape or cord around the yokes will compete the core. In connecting the coils the same procedure should be followed as in connecting up a direct-current horseshoe magnet, the beginning of one coil to the end of the next. Stamp the voltage on the fiber heads near the primary terminals or mark them so there will be no mistake as to which are the high-voltage connections.

Effect of Fuel Consumption on Oil-Engine Reliability

By Ralph Miller*

The oil engine in these days of high efficiency requirements is becoming more widely used as a prime mover. Scores of makes, representing many variations in design and principle, are being manufactured. The prospective user of an oil engine, who in many instances does not understand the theory of the internal-combustion engine, is confronted with confusing problems. Often it would seem that the higher fuel economy obtainable with some engines does not justify the increased price over a less economical machine.

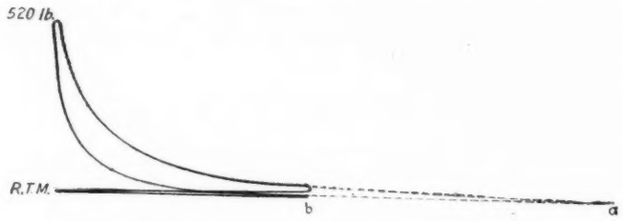
One should be guided primarily by the power requirements. In a few situations an oil engine of low initial cost, having a rather high fuel consumption as well as being somewhat less dependable, may serve the purpose better than a highly efficient engine, when viewed from the point of over-all cost. This applies to installations

*Experimental Engineer, Ingersoll-Rand Co.

when the engine will be operated only for a short part of the year, and where shutdowns are not of great moment. However, in the majority of plants the demand is for a highly dependable oil engine. Interruptions caused by engine troubles invariably mean a financial loss to the owner. The ice plant cannot suffer a stoppage without a direct loss. In the electric-light plant and other industries shutdowns are to be avoided, since they mean loss in output and in idle labor charges. In one silver mine where oil engines are used, the stoppage of a 100-hp. unit entails an hourly labor loss of $150.

Dependability and Reliability

What, then, are the outstanding features whereby the purchaser can determine if the engine is a dependable one? It can be stated as an axiom that, with all other factors being equal, as the thermal efficiency of the oil engine is increased its dependability and reliability are raised in direct ratio. This on the surface



OIL ENGINE WITH COMPLETE EXPANSION

appears to be a radical statement, but on due deliberation the investigator will conclude that it is true. The explanation is neither new nor novel, but on the other hand is based on common sense.

Engineers well know that theoretically a perfect engine would require 2,545 B.t.u. per hour for each horsepower developed. Fuel or crude oil contains at least 18,500 B.t.u., ranging upward to 20,000. Obviously, the perfect oil engine should consume only $\frac{2,545}{18,500}$ or 0.14 lb. per horsepower per hour. Such ideal conditions are not obtainable for several reasons: First, the temperature of combustion in the cylinder is much above the melting point of the cast iron of the walls; this necessitates the cooling of the cylinder. The cooling water will absorb around 30 per cent of the heat generated in the burning of the oil. Secondly, it is impossible to expand the gases down to atmospheric pressure, since this will require a cylinder with abnormal dimensions for the power output.

Diagram from Solid-Injection Engine

In the illustration accompanying this article is shown an indicator diagram from a solid-injection oil engine. The dotted line indicates the additional cylinder stroke needed if the expansion was carried to atmospheric pressure at *a*, the volume at *a* being 2.175 times the volume at *b*, while the additional power secured is very small. The expelling of the gases at a somewhat high pressure and temperature results in a loss. The exhaust temperature is around 700 deg. F., causing a loss of about 30 per cent of the B.t.u. in the fuel. These two losses, cooling and exhaust losses, absorb some 60 per cent of the heat contained in the fuel. There are several other minor losses, such as radiation, formation of H_2O, but these need not be considered. With 60 per cent loss there remains about 40 per cent of the fuel heat that is converted into work. Instead of requiring only 0.14 lb. of oil per horsepower-hour, actually there is needed $\frac{0.14 \times 100}{40} = 0.35$ lb.

This represents the fuel to develop a horsepower in the cylinder. The mechanical efficiency of the engine will be around 80 per cent. To deliver a brake horsepower necessitates the consumption of, not 0.35 lb., but 0.43 lb. per hour.

There are many types of oil engines on the market, ranging from the modified gasoline engine using kerosene to the highly developed high-compression unit. The fuel consumption of brake horsepower varies with the design from 1 lb. to 0.38 lb. per brake horsepower. The engineer will naturally wonder what becomes of that amount of oil over and above 0.43 lb. which is being forced into the cylinder, especially in engines using from 0.8 to 1 lb. per brake horsepower. After having paid the oil company for the excess fuel, the matter is not ended. This surplus oil, in some cases running as high as 0.6 lb. per horsepower, or 60 lb. per hour in a 100-hp. engine, cannot disappear without leaving some visible traces.

A part of the excess oil remains in the combustion cavity and on the piston in the form of carbon deposits. This carbon builds up thicker and thicker upon the walls, causing sticky piston rings. Loss of compression naturally follows as also does retardation of the heat transfer through the cylinder walls to the cooling water, since carbon scale is an excellent nonconductor. The cylinder and piston overheat, the piston often seizes, and liners or exhaust ports fracture, while preignition is of frequent occurrence. Other parts of the excess oil pass out through the exhaust as smoke, choking up the passages, with a loss of power.

Obviously, the heavier the fuel oil is the harder and more profuse does this carbon formation become. The very features responsible for the burning of excess fuel necessitate increased amounts of fuel if the oil is very heavy.

The Efficient Engine Is Economical

In addition to comparative freedom from operating troubles the efficient oil engine has the advantage of being economical in fuel costs. It is evident that a 100-hp. engine running fully loaded and consuming 0.45 lb. per hp.-hr. saves $4 on the fuel cost each ten-hour working day with oil at ten cents a gallon. An additional advantage lies in the ability of the efficient engine to use heavy oils. For example, Mexican and California crude oils are successfully used in the Diesel and solid-injection engines, while less economical units fail to function properly on the same oils. The saving obtainable is not only the actual decrease in the fuel consumed, but the lower cost of the heavy oils. This would in many instances produce a total saving of $10 per day in the 100-hp. engine cited. Briefly, the advantages of a high-economy engine are: Lower fuel cost, since it uses less oil and a cheaper oil; lower maintenance costs, due to absence of carbon deposits and consequent troubles; greater reliability.

In running a power plant it is important to have all the men, from the coal passers to the superintendent, familiar with their jobs. They should be trained, so far as possible, for the next jobs above their present ones.

The Relation Between Boiler Efficiency and CO_2

By E. A. Uehling

Concerning the relation between boiler efficiency and CO_2, boiler efficiency is the result of two factors—(a) combustion efficiency and (b) absorption efficiency. Of these two factors (a) is under the immediate control of the fireman; (b) depends on conditions over which the fireman has no direct control.

To secure intelligent and effective control, diagnosis must precede the determination and application of the correct remedy required.

Combustion is a chemical phenomenon and can be correctly diagnosed only by chemical means.

Complete analysis of the products of combustion reveals all the elements required for a scientifically correct diagnosis of combustion efficiency.

Complete analysis of the products of combustion and of the fuel used, together with many other scientific measurements and observations, are necessary when it is desired to establish a correct heat balance. A heat balance is desirable for the purpose of checking the results of scientifically conducted boiler tests.

Heat Balances a Refinement

Heat balances belong in the field of expert boiler testing; they are infeasible in practical boiler operation and are not necessary to the attainment and maintenance of maximum boiler efficiency.

Excessive heat carried up the chimney is the principal cause of low boiler efficiency.

Excess air is the *sole* carrier of all the avoidable heat loss up the chimney, so far as the fireman is concerned.

To insure maximum boiler efficiency the fuel must be burned with the minimum excess air compatible with complete combustion.

To enable the fireman to regulate the air and fuel supply and keep the fire in proper condition to maintain complete combustion with a minimum excess air, he must know all the time whether he is accomplishing this end.

The percentage of CO_2 is a true index of the percentage of excess air supplied. Therefore the CO_2 indicator at the boiler front furnishes the fireman with a continuous diagnosis of the combustion efficiency he is getting, just as the steam gage shows him continuously whether he is maintaining the desired steam pressure.

CO_2 Recorder Comparable with Steam Gage

A fireman cannot be expected to maintain regularly high combustion efficiency without a CO_2 indicator to guide him any more than he can be expected to maintain an even steam pressure without a steam gage.

To judge his firemen correctly the engineer must be supplied with a continuous record of the percentage of CO_2 produced.

The ratio of percentage of excess air to the percentage of CO_2 increases progressively as the percentage of CO_2 decreases from maximum to minimum; therefore, the heat loss based on the average percentage of CO_2 derived from the record will be less than the actual loss due to excess air, and the greater the variation in the CO_2 record the greater will be the error.

For approximately the same average percentage of CO_2 recorded, the most uniform record always indicates the best combustion efficiency.

Unless the autographic record is to be used as a basis for calculating a bonus, a visual inspection of the records will enable the engineer to arrive at a practically correct judgment of the proficiency of his individual firemen.

A fairly equitable bonus system may be based on the average of percentage of CO_2 derived from the charts by employing a proper modifying factor based on the variations of CO_2 that are produced by the individual firemen.

The principal value of the autographic record, however, lies in the fact that it is a continuous minute-to-minute history of the combustion efficiency of every boiler to which it is attached. It enables the engineer, after scrutinizing the records, to go to the boiler room with the confidence born of knowledge and bestow praise, inflict censure and, what is more important than either, assist and instruct the more or less inexperienced of his firemen in the art of firing to enable them to produce regularly that percentage of CO_2 which, with the fuel used and the operating conditions prevailing, will result in maximum combustion efficiency.

CO_2 is a reliable guide to the fireman irrespective of the chemical analysis, heat value or physical condition of the fuel supplied.

The higher the hydrogen carbon ratio in the fuel used the lower will be the maximum percentage of CO_2 attainable with complete combustion, and hence the more important will be maintainance of the correct percentage of CO_2 in the products of combustion.

Autographic Record Gives Full Information

The autographic CO_2 record is the only record obtainable which by itself gives information that requires no additional data for its correct interpretation. It is the only record which by itself shows whether the fuel is burned efficiently or wastefully.

The most efficient percentage of CO_2—that is, the percentage of CO_2 that can be maintained without appreciable loss due to incomplete combustion—will vary: (a) With hydrogen carbon ratio; (b) the physical condition of the fuel, solid, liquid or gaseous; (c) the relation of volume of the combustion chamber to the grate area; (d) the method of firing; (e) the available draft, etc. But for every condition there is a percentage of CO_2 that will give maximum combustion efficiency for the conditions prevailing, and with the CO_2 indicator to guide him any good fireman will be able to do his part to produce regularly the maximum percentage of CO_2 and thus secure maximum boiler efficiency.

The manager of a plant should cause the men to realize that a power plant is a school that runs twenty-four hours a day and seven days a week. Efficient, experienced men are hard to get, and it may pay to have a school on the company's time, give the men lists of questions to study or pay for some courses in a correspondence school. Under any condition the superintendent should post near each machine instructions on its operation, care, maintenance and idiosyncrasies.

The Colorado Engineering Council, composed of representative engineering societies in Colorado, including mechanical, electrical, mining, chemical and minor branch societies, recently indorsed the proposed revision of the State Engineer's License Law, including the creation of a board of examiners for engineers.

EDITORIALS

Properties of Arc Welds

AUTOGENOUS welding has for a number of years been a frequently discussed subject, and although much has been learned from practice and investigation, there are still many open questions regarding the art. It has become well recognized that as long as welds are made by an operator, the quality of the work depends to a large degree on the welder.

It has been estimated that each pound of metal deposited by a metallic-electrode arc welding process is transferred in the form of approximately thirty thousand globules. The character of each one of these globules depends upon current density, lengths of arc, method of manipulating the arc, etcetera; consequently, the importance of the operator in making the weld is evident. The preferred method of building up a surface or filling in a joint is to deposit the arc metal in layers and to clean each layer thoroughly before depositing the next. Since the complete weld is in the form of layers made up of many small globules, it is apparent that it will develop different characteristics when subjected to stress in different directions. What these characteristics are has been determined by O. H. Eschholz, and they are presented in the leading article, "Properties of Arc Metal and Arc Welds as Determined by Tests," in this issue.

The welds were tested in three directions—parallel to the length of the weld, in a plane parallel with the layer surfaces, and in a plane at right angles to the layer surfaces. The second of these tests is of greatest importance when applied in a tensile stress, since this is the main stress set up in all welded pressure vessels. As might be expected, the weld, when stressed in this direction, is not so strong as when stressed in the direction of the weld. Although this difference, as shown by tests, is not a serious one, being in the neighborhood of nine per cent, it does suggest, as pointed out by Mr. Eschholz, that the metal should be deposited so that the greatest stress will be in the direction of deposition. When this is not possible, the number of layers in series may be reduced by widening the deposit. What was of far greater importance in these tests was the difference in tensile strength of metal deposited in layers and in bulk. The bulk-deposited metal could stand an average of only about sixty per cent of the stress applied to the layer-deposited metal. The bulk-deposited metal also gave indication of being brittle, since its elongation averaged only twenty-four per cent of that for layer deposition. These tests clearly show what a marked influence the method of deposition of the metal has on the strength of the weld.

The conclusions drawn by the author with regard to fatigue are interesting in that they bear out the position taken by many engineers as to stressing welds. "Available test data comparing the fatigue performance of welded and unwelded metal are too incomplete to warrant the drawing of definite conclusions. It is, therefore, advisable for welding engineers to scrutinize carefully each live-load application and, where permissible, design the joints or reinforce the weld so as to reduce unit stresses at the welded area and transfer the load to a stronger member."

Mr. Eschholz has undoubtedly thrown light upon many features of arc welding which will be of great help to an understanding of how these welds may be expected to act under given conditions, thus making an even greater application of the electric arc to joining metals.

National Board of Boiler and Pressure-Vessel Inspectors

THIS organization of the boiler-inspection departments of the country is now practically ready to function. It has taken the year or more since its organization for it to find itself, to determine what service it can best render and how best to go about it.

Naturally, the first benefit to be expected from an association of state departments is a simplification of interstate relations. All of the departments, of the heads of which this Board is composed, have accepted the Code of the A. S. M. E. If a boiler is built in accordance with that Code, it will be acceptable to the departments of seventeen states and twelve smaller political divisions represented on the Board. When all the states are in, an A. S. M. E. Code boiler will be acceptable anywhere. In view of the fact that at the start of the unification movement it was impossible to build a boiler that would be acceptable in all of nine states, this would be an admirable solution.

But how is an inspector to know that a boiler has been constructed in accordance with the Code? This cannot be told by inspection after the boiler is finished, but involves inspection during construction. How is the head of the inspection department of the state into which a boiler comes, to know that it is a Code boiler? He cannot afford to maintain an inspector in every boiler shop in the country nor to send an inspector to a distant state in which is being built a boiler that is to come to his state. The obvious thing is reciprocal inspection service in interstate boilers; that is, boilers built in one state for use in another. The inspector of the state into which the boiler is going may accept the certificate of an inspector in the state in which the boiler is made that it is made in accordance with the Code. This he can do if he is satisfied that the inspector is dependable. The organization just effected opens the way to mutually satisfactory qualification of inspectors and an agreement for interstate acceptance of their findings.

There must, then, be some arrangement whereby a boiler constructed in accordance with the Code may be recognized as such wherever and whenever it may be found. The present multitudinous requirements of the individual states have led to a deplorable condition. Several instances were mentioned at the organization meeting reported elsewhere in this issue, of boilers carrying twenty-odd state and city stamps. The National Board offers a service that will do away with this bungling system, or lack of system, and make it

possible for the boiler manufacturer to stamp his product when completed with a symbol and identification number, which in connection with the data sheet, simultaneously filed with the secretary of the National Board, would identify the boiler bearing such symbol and number wherever found and assure its acceptance as a Code boiler in any of the political divisions represented on the Board. This service ought to be of real value to boiler manufacturers, especially to those building in large numbers for stock and will be of increasing importance as boiler-inspection legislation becomes more general.

Legislation by Indirection

ONE of the most vicious practices in which our national legislators indulge is again shown by the form in which the Senate proposes to provide money for the next year's operation of the Federal Power Commission. In the Sundry Civil Appropriation Bill it is recommended that this Commission be given $80,000 in a lump sum and a limited number of positions which are provided for by specific appropriation. For example, the committee provides a chief accountant at the munificent salary of $3,000; two attorneys at $2,500 each; a civil engineer at $2,400; another civil engineer at $2,100; one hydraulic engineer, one electrical engineer and one mechanical engineer, each at $2,400, and also a few other minor positions. For a commission which is to handle business affairs involving literally billions of dollars of construction such salaries are absurd.

The Federal Power Commission bill was before Congress for an extended period. The opponents of the bill had every opportunity to debate it and to defeat it if they could muster arguments and votes sufficient to that end, but the bill passed and became a law. Now these same opponents, by malicious methods of appropriation, provide for the enforcement of the legislation a staff which is not only inadequate, but actually dangerous to the country. In its desire to retain detailed control over the executive-department affairs, Congress has long retained the system of "statutory salaries," for which definite appropriation is made for specific positions of fixed salary. By following this system Congress assumes that the executive officers of the departments are not competent to judge what class of employees are needed or what salaries should be paid to them. In the present case this system will in effect repeal the Power Commission legislation. For with the salaries proposed by the Senate, the Power Commission might as well lock its doors and take a vacation. The possibilities of good are almost nil with such a staff; the possibilities of evil through incompetent effort at something beyond the capability of the staff are infinite.

Business men of the country can well appreciate the absurdity of the present Congressional system. It would be as wise for the board of directors of the United States Steel Corporation annually to fix the number of office boys, the number of stenographers and salary for each, for every subsidiary or department or office of the company as it is for Congress to attempt to fix salaries and exact numbers of employees according to the system which they attempt to use. No big corporation undertakes such a scheme. The business man knows he must hire a manager who is honest and who has brains and then permit him to use his ability in the interest of the company. We wonder if Congress cannot some time be persuaded to be equally intelligent in the managing of the biggest business affairs of the country—the affairs of our Government. In any event it is high time that the system of petty control of salaries ceased to be a potential power for repeal of legislation. Legislation by indirection of this sort is vicious; it should immediately cease.

"Promptly at Ten"

CONVENTIONS we have ever with us, and probably shall have so long as man continues to be a gregarious animal.

To the tried and seasoned convention attender the title of this editorial is at once a joke and a text; to the average citizen of a convention city it represents a delusion and a snare. The hardened convention goer can picture the usual scene. At ten-thirty there are a few society officials and employees in the corridors and offices, but no one in the convention hall except a bored-looking hotel attendant picking up papers and generally putting things to rights. At ten-forty the chairman takes his desk. At ten-fifty he gives an apologetic whack of the gavel and requests the "meeting" to "please come to order." At eleven or thereabouts, after the gentlemen near the door have been shooed into their seats and only those in the back rows are carrying on a really animated conversation, the "first paper of the morning" is announced as having been "crowded out of the program" on the day previous.

And so it goes, for one session after another, year after year, and for some queer reason engineers seem to be the worst offenders. A statistician could make a splendid story out of the hours wasted by lack of punctuality, misplaced conversation, and not limiting discussion to its proper channels.

Some day a committee of arrangements will cover itself with glory and win golden encomiums from all concerned by running a meeting on scheduled time. In the line of constructive suggestion a thoroughly experienced stage manager might be secured for the purpose. Personal feeling will thus be avoided, train-dispatching methods will hold speakers to a predetermined schedule to the pleasure and benefit of the public and society members alike, and Mr. Busy Engineer will hear the paper he wants to hear, instead of losing a whole forenoon, and his temper to boot.

Systematic and periodic inspection in water-power stations is just as important as in steam plants. In the latter the coal bill serves as a barometer of operating efficiency, but in the former there is no such visible indicator. This fact is fully appreciated in the large hydro-electric plants and systems, where every effort is made to extract the last horsepower out of the white coal with a realization that it has a dollars and cents value just as does the black. Many of the smaller plants, however, are let run without attention as long as the wheels will turn, without a thought as to how much of the energy of the water is being wasted.

The engineering problems incident to a superpower system appear to have been satisfactorily solved; attention is now being directed to the financial aspect of the proposal.

CORRESPONDENCE

Unbalanced Throttle Valve on Large Engine Stops

George Van Vlack, in *Power* of Jan. 11, says that he believes the reason the automatic stop mechanism failed to close the throttle in the case mentioned, was on account of the throttle being of the unbalanced type.

The remarkable thing about the affair is, if the differential was as great as Mr. Van Vlack figures it, that he was able to close it himself, although he could have made use of a bar or wrench on the valve wheel. Practically all engine stops using a weight for closing the valves possess considerable power; in fact, as a general thing more than does mere man.

Quite frequently, stops will act in the erratic or pulsating manner mentioned, but it will be found to be due to friction in the cushion chamber and never by the so-called unbalanced action of the valve.

Louisville, Ky. JOHN F. HURST.

Why Exempt Oil-Well Boilers?

An editorial in the Nov. 2, 1920, issue of *Power* asks the question, "Why Exempt Oil-Well Boilers?" This is easy to answer: inspection laws are made by politicians so that they will not hurt anyone. The ordinary oil-country boiler is a firebox type, about 13 ft. in length and 42 in. in diameter, and with a few exceptions constructed of flange steel. The barrel is double-riveted lap-jointed, and the holes are not drilled but are punched and are not reamed. The boilers are tested in the shop to a pressure of 150 lb. By the A. S. M. E. Code formula the longitudinal seam is good for 125 lb. pressure using a factor of 5, although such is not always the case, as the pitch and diameter of the rivets vary with the make of the boiler.

The weak part of this boiler is the crown sheet, and the stays rarely are good for more than 112 lb., though we assume they are made of firebox steel. The boilers are operated by men who know little of engineering, and the running of the boilers is only incidental to their work of drilling or tool dressing. Not one man in a hundred knows whether 100 or 1,000 lb. pressure should be carried.

In 1917 the Commission of the Department of Labor and Industry of Pennsylvania requested the writer to supervise the inspection of boilers in western Pennsylvania that were not inspected by any insurance company. The owners of the oil-well boilers refused to have them inspected. I retained an attorney to prepare a brief to the Attorney General and the Commissioner of the Department of Labor of Pennsylvania to show cause why this type of boiler should not be inspected. The Attorney General ruled that they were subject to inspection by inspectors who had been examined and approved by the Department of Labor. I then had my inspectors examined and approved and began the inspection of these boilers, as not one in 500 was insured by a boiler inspection and insurance company.

Every obstacle was placed in my way to prevent the boilers being inspected, and I held up a great many certificates until repairs were made. Many of the boilers had to be inspected externally as the owners would not give the location of the boilers and the inspectors had to do the best they could. Sixty per cent of the boilers were found to be in a dangerous condition; 33 per cent had buckled crown sheets and 20 per cent had a cock or valve between the boiler and the safety valve. Many safety valves were found inoperative, and in some cases there were no gage cocks.

The large companies soon found that it was to their interest to have an inspector make annual visits and report in full to the office, and where this was done, in 1918, the men in charge of the boiler watched for the inspector and had their boilers in fair shape because they knew they would be reported to the man above.

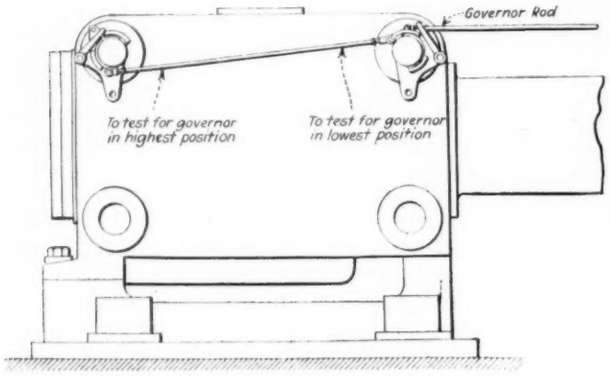
In January, 1919, conditions were in much better shape and matters appeared to be going fairly well. But the legislature was in session and I heard that an attempt would be made to amend the bill exempting oil-well boilers from inspection. I prepared a statement calling attention to the fact that the boilers they proposed to exempt were the most dangerous of any in operation and sent it to the Supervising Inspector of Boilers for Pennsylvania with the request that he give it to the man who had charge of the bill, see the Governor and arrange for me to meet the committee. After holding my letter for some time, the Supervising Inspector wrote that he had given the statement to the Chief of the Bureau of Inspectors. I saw no more in the daily papers regarding the bill until after the legislature had adjourned, when I was advised that the Governor had signed a bill exempting oil-well boilers from inspection. I spent more than $500 in having the Attorney General render an opinion that these boilers should be inspected and then had it all killed by an amendment.

So I say, when laws are made for the preservation of life and property and not for the prevention of somebody's "rights" as they think, we may have good boiler laws. CHARLES H. GARLICK.

Pittsburgh, Pa.

Testing Governor and Valve Adjustment

An easy way to test governor and valve adjustment on the design of engine shown by the sketch is as follows: In order to see if the governor cuts off completely when at its highest point pull the governor rod toward the crank end. If the steam is completely cut off it may be assumed that the engine is safe in case of sudden loss of load or breaking of the main belt. To test for safety in case the governor belt breaks, move the rod in the opposite direction, or toward the head end,



TESTING FOR SAFETY CAM ADJUSTMENT

bringing the governor to its lowest position. If properly adjusted the valves will not open. If they do open it means that the cams are not high enough. As the cams are usually faced with fiber, putting shims under the fiber will raise them.

This method of testing is not to be recommended if the engines are driving generators in parallel, especially alternators. R. McLAREN.

Toronto, Ont., Canada.

A Strange Idea for Saving Fuel

The illustration shows a side view of the furnace and bridge wall of two 72-in. x 18-ft. return tubular boilers, originally erected with a 6 x 6-ft. furnace. The two boilers, as far as I can learn, were operated under natural draft and were too large for the load. As one boiler was considered too small to do the work, both were used.

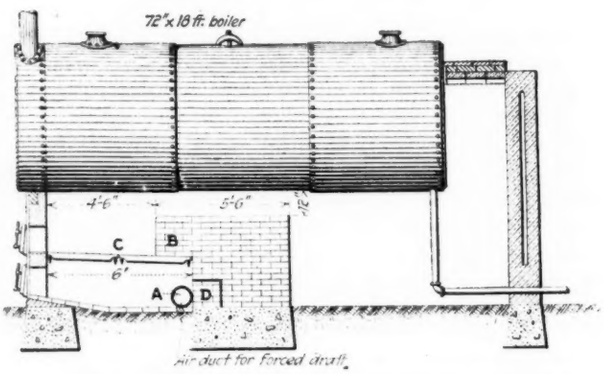
It was claimed that considerable fuel was wasted because the grates were too long and the fireman was unable to keep the grate surface covered. Therefore the engineer had a mason build the bridge wall out over the grates *C*, as shown at *B*, making the top of the bridge wall 5½ ft. thick and the grates only 4½ ft. from the front arch to the bridge wall, leaving but 27½ sq.ft. of grate area instead of 36 sq.ft. as before. This area was further reduced by the accumulation of clinker on the front of the bridge wall, which extended out over the grates never less than 6 in. and often as much as 10 in. in width.

As the boilers steamed better than before the change, it was generally conceded to be a good job. That a 6-ft. furnace was too long for a 72-in. boiler was the general opinion of all except the builders, who were then out of business.

In a short time the load increased considerably and the firemen began to migrate one after another about as fast as they came, and none of them could keep up steam. The load had increased so much that the boilers required the full grate area. As the firemen could not keep up steam, a 30-in. diameter home-made fan blower was put in place, and an effort was made to cut an air duct through the bridge wall for a forced draft to the ashpits. After some cutting through the side wall had been carried on, it was decided to run a metal air duct along the front of the bridge wall of No. 1 boiler and through the side walls just in front of the bridge wall, in the ashpit of No. 2 boiler, as at *A*.

If the forced draft had been installed at the start, one boiler could have done the work with its 36 sq.ft. of grate surface, as more coal could have been burned with forced draft than could be burned with natural draft. Most of the coal waste was because the firemen did not keep the back of the grate thoroughly covered with fuel, and of course cold air rushed into the furnace, the steam dropped and the fuel was wasted in the attempt to keep up steam. By building the bridge wall out over the grate bars 1½ ft., the grates were easily kept covered with fuel and the boiler seemed to steam better and, by weight, burned less coal. The 1½-ft. extension of the bridge wall over the grate, with 6 in. additional clinker reduced the grate area 12 sq.ft. and left but 24 sq.ft. of working grate area. Allowing 30 sq.ft of heating surface per square foot of grate area for a power boiler, the reduced capacity would be equivalent to a reduction of 360 sq.ft. of heating surface for both boilers due to building the bridge walls out over the grates.

The builders' rating was 1,250 sq.ft. of heating surface for each boiler, and when this capacity had been reached there was further demand for additional steam for new equipment, but no new boilers could be installed, even if they could have been obtained in war time. The addition to the bridge wall was removed and firemen engaged who had muscle and experience enough to put



BRIDGE WALL EXTENDED OVER THE GRATES

the coal back over all the grate area and get full steaming capacity out of it.

The air duct should have been cut in under the edge of the bridge wall as shown at *D*, or it could have been run beneath the floor in front of the boilers and an outlet cut under the front castings into the ashpits and dampers put on the outlets. The grates were found in very bad condition upon removing the false bridge wall, but it is no trouble to keep steam up now, even with bad fuel; furthermore, the boilers can be worked up to and above their rated working capacity without excessive labor on the part of the firemen. R. A. CULTRA.

Cambridge, Mass.

Two Elevator "Stunts"

We have several buildings rented for light manufacturing purposes. Each building is equipped with a motor-driven passenger and a freight elevator. The latter is operated by anyone who wishes to use it, and at times it has to stand rough treatment. In Fig. 1, *A* shows where the original slack-cable device used to be, but it got caught and broke the casting so badly that a good repair job was impossible.

The elevator inspector refused a certificate until the machine was equipped with a slack-cable device, therefore the rig shown in Fig. 1 was put on. It consists of a $\frac{5}{8}$-in. rod suspended from the beam overhead, two grooved pulleys running loose on the rod, and two weights. One end of the rod is connected by a cord to the handle of the magnetic switch on the line to the motor. Should the hoisting cables become slack, the weight pulls the rod to one side, and opens the magnetic switch, thus cutting the current from the motor.

The machine has a mechanical brake, but owing to a small driving pulley and to a slow-running car (about 75 ft. per minute) the motor quickly comes to a stop. This device worked so well for the state inspector, who tried it several times, that he did not hesitate about

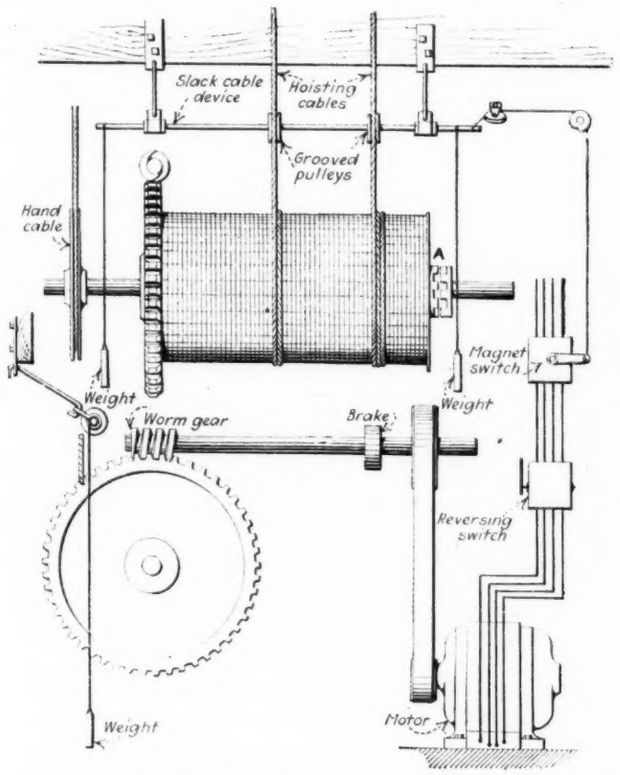


FIG. 1. SHOWING DETAILS OF THE SLACK-CABLE DEVICE

issuing a certificate, as the machine complies with the state elevator laws.

We had considerable trouble with the rig shown in Fig. 2, which was put on when the machine was changed over from a double-belt drive, run from the lineshaft, to a motor drive. The device is shown in the neutral position. As the hand cable is operated to start the car, the sheave is moved around about a quarter turn and releases the brake through a cam (not shown) and changes the reversing switch in the desired direction. At times the men would pull the hand cable with such force that the pins would be pulled away from the tripod and tip it up or down, and would not go back in their proper place when the car was to be stopped. As the brake and current would be on at the same time the automatic switch had to come out or a fuse blow. At other times the pins would get stuck on the ends of the

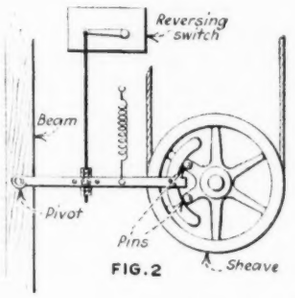


FIG. 2

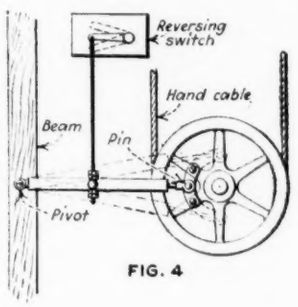


FIG. 4

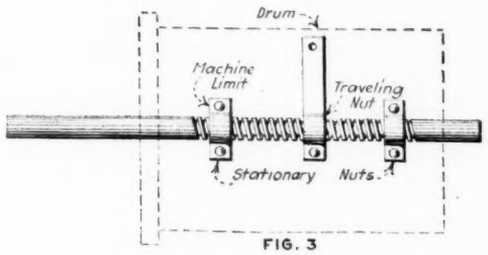


FIG. 3

FIGS. 2 TO 4. DETAILS OF THE STARTING AND STOPPING GEAR

Fig. 2—Old gear that would catch. Fig. 3—Machine limit device. Fig. 4—Improved starting and stopping device.

tripod and prevent the hand cable from being moved, and the car would keep going until the machine limits, shown in Fig. 3, were reached, and something would have to give before the machine would stop.

The arrangement shown in Fig. 4 stopped the troubles and saved many an elevator repair bill. It worked so satisfactorily that it was put on all the machines that were equipped like Fig. 2. It consists of a piece of $\frac{3}{4}$-in. pipe and a $\frac{5}{8}$-in. rod working telescope fashion. The end of the pipe is flattened for a hole where it is bolted to the beam, and the end of the rod is fastened to a pin that is secured between the spokes of the sheave wheel.

Springfield, Mass. THOMAS SHEEHAN.

An Unusual Boiler Failure

In the Jan. 4 issue of *Power*, page 27, reference is made to the distortion that took place in the upper part of the shell plate of a water-tube boiler. The failure is termed unusual, but as a matter of fact it is quite common. The photograph reproduced in the article could be used to illustrate similar damage that has resulted recently to ten or twelve boilers in widely separated localities, due to the same cause.

Investigations that have been made following accidents of this description do not indicate that the overheating of the shell plate was the result of the ignition of soot or other deposit that had lodged upon the upper part of the boiler, but rather to the continued high temperature of the flue gases.

In one plant, where six boilers were affected in this way, it was found that no serious difficulty had been experienced during the time the boilers were being operated under normal load conditions. An enlargement of the shop had caused an increased steam con-

sumption, so high-duty stokers were installed under th boilers to provide the additional evaporation without increasing the boiler capacity. The soot that had ac cumulated in the past had been removed each time a boiler was cleaned, for the soot acted as a non-conductor of heat, and it was the owner's intention to obtain the greatest possible amount of heating surface. There is no doubt that the upper part of each boiler, where exposed to flue-gas temperature, was reasonably clean when the bulging took place, so the difficulty could be attributed directly to the high temperatures resul'ing from the overloaded conditions.

During the coal shortage many plants were provided with oil burners, as oil fuel could be obtained and was used in lieu of coal, which was unobtainable. The furnaces were not designed for oil fuel, so the breeching temperatures were much higher than they had been during the time coal was consumed. In one plant that had made the change to oil fuel, two boilers were damaged; in another plant one boiler was damaged by the bulging of the upper part of the drum-shell plate beneath the breeching.

At the rear end of a water-tube boiler with a level drum, the circulation of the steam is not sufficient to prevent the shell plate from overheating when it is exposed externally to high temperatures. It is for this reason that boiler inspectors have been cautioned to be on the lookout for installations where the products of combustion pass over the uninsulated steam spaces of the boilers examined. All parts exposed to the products of combustion should be protected by water; if not, they should be insulated from the gases.

This instruction, of course, would not apply to superheating elements, because the circulation of steam in superheaters is rapid and positively directed, so that the steam can be depended upon to prevent a dangerous increase in temperature in the walls of the superheater tubes unless the external temperatures are abnormally high.

J. P. MORRISON.

Chicago, Ill.

How Much Does an Ashpit Door Cost?

On the "Foreword" page of *Power*, Jan. 18, the question is asked, "What Does a Pound of Babbitt Cost?" This brought to mind a question I asked a prominent boiler manufacturer: "How much does an ashpit door cost?" He immediately began to figure mentally on the size and weight of ashpit doors, and when I told him I did not want to know how much I could buy ashpit doors for, but simply how much they cost, he appreciated the importance of my question and said he had never thought of that before.

This was brought about by a little investigation I was making at the time at a certain plant. When the steam went up to near the point where the safety valves would lift, the fireman would kick the ashpit doors shut. Upon asking him why he did that, he said that the steam was up. I asked him how long he had been doing that, and he said for nearly eighteen years, as he had been fireman there for that length of time.

I asked the man in charge of the investigation if he did not believe that those ashpit doors had cost him more than the boiler. He replied that it would be very hard for him to believe that. However, in order to prove it I drew a sample of gas from a point on the boiler side of the damper and got 7 per cent CO_2. I asked the fireman to open the ashpit doors and without making any further change the CO_2 content was 12 per cent. It was hard for them to realize then until I pointed to a number of cracks in the boiler setting. This made it very plain to them, and they immediately took steps to arrange the damper so that it could be conveniently operated instead of closing the ashpit doors.

I believe that this case is only one of many where the fireman uses the ashpit doors instead of the damper. It does not require any great study to see the fallacy of this. I am quite sure that coal could be saved in many places if more attention was given to the damper and the ashpit doors removed entirely.

Philadelphia, Pa. G. F. DUEMLER

Lack of Circulation Prevented Water Heating

The hot-water supply for a group of buildings was furnished by individual heaters and storage drums in the basements of the various buildings. The units were of a type having a 1,000-gal. storage drum connected to a heater located about three feet directly under the drum. The heater was a 10-ft. length of 12 in. pipe flanged at both ends, with a steam coil made up of eight 9-ft. lengths of 1½ in. pipe. This coil so nearly filled the heater that after a few months of operation enough scale would collect to clog it entirely. As the rooms were very small, it was necessary to disconnect the heater and remove it from the room before the coil could be taken out for cleaning. This job usually took two men two days, during which time the building was without hot water.

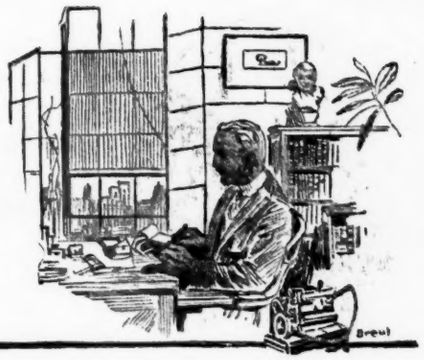
To remedy this condition, two 1½-in. couplings were welded into the drum heads and a coil of 1½-in. pipe was then made up and placed inside the storage drum. The old heater was then removed and the steam turned on the new coil, but the results were unsatisfactory. The temperature would run up to 240 deg., and when the thermostat was cut down the water would not heat at all. There were also complaints that the water did not stay warm, as it formerly had done, after the steam was shut off at night.

Upon examination it was found that the trouble was due to the fact that the cold water was taken in at the bottom of the drum, and as the steam coil was near the center, the hot water went to the top of the drum, where the thermometer and outlets were located. Of course there was very little circulation set up, and as the thermostat that controlled the steam to the coil was located below the center of the drum, it was not affected by the hot water at the top of the drum, consequently the temperature varied from 240 deg. at the top to the temperature of the cold-water supply at the bottom. To correct this fault, the cold water was taken in at the top of the drum and a header of 1½-in. pipe, capped at the end and drilled with seventy-five ¼-in. holes, was run parallel with the steam coil about four inches from the top of the drum, so that the cold water would spray directly down the steam coil and thus set up a rapid circulation. This solved the problem, and the drums now heat evenly from top to bottom and the scale is easily removed through the manhole.

Norwalk, Cal. A. C. MCHUGH.

There is danger, in case a Diesel fuel valve wedges open, that the flame in the engine cylinder may travel back along the air lines. If any lubricating oil is left in the air line, air explosion will follow.

INQUIRIES OF GENERAL INTEREST



Rating of Refrigerating Machine—What is meant by a twenty-ton refrigerating machine? W. L. A.

A twenty-ton refrigerating machine is one that produces a refrigerating effect at a rate equal to the melting of twenty tons of ice per 24 hours. A pound of ice in melting requires a quantity of heat known as the latent heat of fusion, which amounts to 144 B.t.u., and twenty tons of ice would absorb $20 \times 2{,}000 \times 144 = 5{,}760{,}000$ B.t.u.

Object of Double-Ported Engine Valves—What is the object of providing an engine with double-ported valves? A. H.

The purpose of using a double-ported valve is to obtain the desired area of opening with half as much movement of the valve, thereby reducing the loss from friction and wear of the rubbing surfaces and securing the advantages of providing a single-ported valve with twice the length of port opening.

Improving Soiled Tracings for Blueprinting—How can tracings, spoiled and crumpled from use, be improved for obtaining blueprints? H. T. T.

Most of the grease and dirt can be removed by lightly rubbing off the tracing with a tuft of clean absorbent cotton moistened with gasoline. After being cleaned and dried, the tracing can be flattened out by ironing the back with a sadiron, which should not be so hot as to impair the transparency of the material.

Voltage Drop in Field Winding and Rheostat—In a direct-current generator how does the voltage drop in the field rheostat compare with that in the field winding? F. M.

If the generator is shunt-wound, it is customary to design the field rheostat to absorb about one-half of the line voltage, while in compound-wound generators this is usually reduced to about one-third of line voltage. The voltage drop in the rheostat will therefore be equal to that in the field winding in the first case and to one-half of the drop in the field in the second case.

Necessity for Air Pump with Surface Condenser—Why is it necessary to use an air pump with the surface condenser of a condensing engine? H. M.

Air or other gases held in suspension in the boiler-feed water are finally discharged with the exhaust into the condenser, and in addition, atmospheric air finds its way to the condenser through leaks of the piston-rod packing and joints of connections with the condenser. Unless the gases thus accumulating in a condenser are removed as fast as received, their presence causes an increasing loss of the vacuum obtained by condensation of the steam.

Loss in Direct-Current Motor at Different Speeds—Is there any loss of power if the speed of a direct-current motor is changed from normal speed, by introducing resistance into either the field or armature circuit? E. N.

The power loss at different speeds in a variable-speed direct-current motor depends on the method of speed control. If the speed is controlled by varying the field strength, the efficiency will be approximately the same at all speeds, provided the current drawn by the machine remains constant. If the speed is regulated by means of a rheostat in the armature circuit, the power loss is equal to that absorbed in the rheostat. If the current is kept constant, the power lost is directly proportional to the voltage drop in the rheostat, and therefore to the drop in speed, since the latter is proportional to the voltage drop in the resistance.

Gain from Higher Temperature of Feed Water—In generating steam at the pressure of 150 lb. gage, what is the percentage gain of fuel economy from supplying boiler-feed water at the temperature of 190 deg. F. in place of 150 deg. F.? J. B. T.

A pound of dry saturated steam at the pressure of 150 lb. gage, or 165 lb. per sq.in. absolute contains 1195 B.t.u. above 32 deg. F., and with feed water at the temperature of 150 deg. F., or $150 - 32 = 118$ deg. above 32 deg. F., the generation of a pound of steam requires $1195 - 118 = 1077$ B.t.u. When the temperature of the feed water is 190 in place of 150 deg. F., each pound of feed water for conversion into steam would require $190 - 150 = 40$ B.t.u. less and the gain in fuel economy would be $40 \times 100 \div 1077 = 3.7$ per cent.

Equalizing Cutoff of Single-Valve Automatic Engine—How can a single-valve automatic engine have the valve set to obtain the same point of cutoff in both ends of the cylinder? H. M.

The cutoff can be equalized for a given load by correctly adjusting the length of the valve rod, but with most valve gears there is some variation of the relative cutoff for different loads, and it is best to obtain equality of cutoff when guided by indicator diagrams taken when the engine carries the average load. In the absence of an indicator, make a mark on the crosshead and corresponding marks on a guide to register when the piston is at ¼ stroke from each end of the cylinder. Then, with the piston in one end, turn the wheel forward until the mark on the crosshead comes opposite to the mark that determines completion of ¼ stroke from the same end of the cylinder, and with the crosshead held at that point, block the governor to a position that will cause the valve to be just closed. Next, turn the wheel forward past the dead center of the other end of the cylinder until the mark on the crosshead comes opposite to the mark on the guide corresponding with ¼ stroke from that end, and observe whether the valve just covers the steam port to the same end of the cylinder. If the valve has been carried to a different position, adjust half of the difference by lengthening or shortening the valve rod. Then reblock the governor so that the valve will be just closed and thus readjust the length of valve stem and governor blocking with the piston at ¼ stroke alternately from opposite ends of the cylinder, until the same blocking will just obtain closure of the steam valve for ¼ stroke from either end of the cylinder.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

JOSEPH F. SCOTT
Chairman

National Board of Boiler and Pressure Vessel Inspectors Organizes

Detroit Meeting Fills Long-Felt Need for Permanent National Body of Boiler Inspectors

C. O. MEYERS
Secretary-Treasurer

THE first annual meeting of the National Board of Boiler and Pressure Vessel Inspectors brought together at the Hotel Statler in Detroit on Feb. 2, 3 and 4 about sixty people, including members of the Board itself, of the Boiler Code Committee of the A. S. M. E. and others interested.

The meeting was called to order at 10 o'clock Wednesday morning by Chairman Joseph F. Scott, of New Jersey, who announced its purposes in a brief introductory address. In the absence of the mayor, Police Commissioner Dr. James W. Inches welcomed the visitors to the city.

The entire first day was devoted to the hearing of addresses. Dr. D. S. Jacobus, acting chairman of the A. S. M. E. Boiler Code Committee, told of the genesis and development of the Code, emphasizing the fact that no action had been taken without consideration of all the interests involved, and nothing had been adopted in either the Code or the interpretations from which any member of the committee dissented. The methods of the Boiler Code Committee were described and its interest in the new organization expressed.

Charles E. Gorton, chairman of the American Uniform Boiler Law Society, told of the appointment by Col. E. D. Meiers, when president of the American Society of Mechanical Engineers, of the first Boiler Code Committee, how the society had reached the limit of its functions in the formulation and interpretation of the Code, and the Uniform Boiler Law Society had been organized to promulgate it, and how the National Board of Boiler and Pressure Vessel Inspectors had been organized at the instigation of the American Uniform Boiler Law Society. He told of seeing on his recent trip to the Coast a boiler with the stamps of 22 different states on it, which absurd practice, now not uncommon, would be avoided by the facilities and simple procedure offered by the organization of the National Board.

C. W. Bissell, dean of the Michigan Agricultural College and chairman of the Michigan Board of Boiler Rules, spoke of the advantages of interchange of opinions between members of boiler boards and the necessity for the rigid enforcement of rules adopted by such boards.

J. C. McCabe, commissioner of the City of Detroit, and Chief Inspector of Boilers for the State of Michigan, treated of the qualifications and duties of boiler inspectors.

E. R. Fish, vice president of the Heine Safety Boiler Co., explained still further the advantage of having a single stamp for boilers constructed in accordance with the Code. S. F. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., spoke on the advantages of uniform qualifications for boiler inspectors. F. W. Herendeen, secretary of the National Boiler and Radiator Manufacturers Association, stated the attitude of that industry toward the new Board and the Code to be sympathetic so long as they did not demand inspection for low-pressure heating boilers, and Fred R. Low, editor of *Power*, outlined some of the possibilities, opportunities and responsibilities before the National Board. Wednesday evening was devoted to an informal discussion of the plan and scope of the Board.

All day Thursday the members of the Board attended the meeting and took part in the deliberations of the Boiler Code Committee of the American Society of Mechanical Engineers.

This meeting was held at Detroit instead of, as usual, at the headquarters of the society in New York, to give the committee the advantage of meeting and counseling with these men from all over the country who are enforcing the Code. The range of application and the wide field from which the experience in the administration of the Code placed at the service of the committee was drawn, may be appreciated from the following list of the inspectors present:

Joseph F. Scott, New Jersey; James Neil,[1] Pennsylvania; C. O. Meyers, Ohio; R. L. Hemingway, California; J. C. McCabe, Michigan; Eugene Webb, Missouri; Geo. A. O'Rourke, New York; L. R. Land, Oklahoma; C. D. Thomas,[2] Oregon; E. W. Farmer, Rhode Island; Gerald Gearon, Chicago; James Speed, Erie; W. H. Brooks, Kansas City, Mo.; W. D. Johnston, Nashville; Robt. D. Ridley, St. Louis; Wm. E. Murray, Seattle; A. J. Bell, Allegheny Co., Pa.; D. M. Medcalf,[3] Ontario, Canada; W. G. Matthewson,[3] New Glasgow, N. S.

Thursday evening the Board members entertained their guests at a banquet.

Friday the speeches and discussions of the preceding days crystallized into a definite plan of action adopted by the Board in the following constitution and by-laws:

PREAMBLE

The National Board of Boiler and Pressure Vessel Inspectors is organized for the purpose of promoting greater safety to life and property by securing concerted action and maintaining uniformity in the construction, installation and inspection of steam boilers and other pressure vessels and their appurtenances, and to secure interchangeability between political subdivisions of the United States.

CONSTITUTION

ARTICLE 1

Section 1. *Name:* This organization shall be known as The National Board of Boiler and Pressure Vessel Inspectors.

ARTICLE 2

Section 1. *Objects:* To promote uniform boiler laws and rules throughout the jurisdiction of its members;

To secure uniform approval of specific designs of boilers and other pressure vessels as well as appurtenances and devices used in connection with their safe operation;

To promote one uniform code of rules and one standard stamp to be placed upon all boilers constructed in accordance with the requirements of that code, and one standard of qualifications and examinations for inspectors who are to enforce the requirements of said code; and

To compile official statistics and other data.

[1]Past member.
[2]In place of William A. Marshall.
[3]Non-members.

MEMBERS OF THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

Excepting the Delaware member, not yet appointed, and the St. Joseph member, who did not send a photograph.

ARTICLE 3

Section 1. *Membership:* The membership of this Board shall be restricted to the Chief Inspector, or the official charged with the enforcement of inspection regulations by any political subdivision of the United States that has adopted any of the codes of the American Society of Mechanical Engineers.

Section 2. Such membership shall terminate when such Chief Inspector or other official ceases to be employed by such political subdivision, or when such political subdivision shall no longer accept any of the codes of the American Society of Mechanical Engineers.

Section 3. *Honorary Members:* Any person who renders distinguished service in the promotion of public safety by the procurement of uniform regulations and laws may be elected to honorary membership by the unanimous vote of the Board at a regular meeting.

Section 4. *Associate Members:* Any person who is concerned with or interested in uniform regulations of steam boilers and pressure vessels may be elected an associate member by the Executive Committee, but no such associate member shall be entitled to vote or hold office. Any member who retires from active membership in the Board shall, at the option of such member, be placed on the roll as an associate member. Annual dues for associate members shall be five dollars.

Section 5. *Certificates of Membership:* The Executive Committee of the Board shall provide suitable certificates for the various grades of membership in the National Board of Boiler and Presssure Vessel Inspectors.

ARTICLE 4

Section 1. *Officers:* The officers of this Board shall be a Chairman, a Vice-Chairman, a Secretary-Treasurer and a Statistician.

Section 2. *Election of Officers:* Such officers shall be elected at a regular meeting by a majority ballot, and shall hold office for the period of two years, or until their successors are elected and qualified.

Section 3. Officers shall be elected from the membership of this Board, except that the Secretary-Treasurer and Statistician shall be a present or past member.

ARTICLE 5

Section 1. *Duties of Officers:* Chairman—It shall be the duty of the Chairman to preside at all meetings; preserve order during its deliberations; to appoint all committees; and to sign all records and other documents used in connection with the work of this Board.

Section 2. Vice-Chairman—The Vice-Chairman shall perform all the duties of the Chairman in the case of his absence or disability and in case of the resignation or death of the Chairman shall perform all the duties of that office until such vacancy is filled by an election as herein provided.

Section 3. Secretary-Treasurer—The Secretary-Treasurer shall have full charge of all books, papers, records and other documents of this Board; he shall receive and have charge of all fees and other moneys, and shall pay all bills; he shall keep the minutes of all meetings; and shall keep a full and complete record of all receipts and disbursements; he shall conduct all correspondence pertaining to his office; he shall compile statistics and other data as may be required for the use of the members; and shall perform such other duties as this Board may from time to time designate. In the event of the office of the Secretary-Treasurer becoming vacant before the expiration of the term for which he was elected, the Executive Committee shall appoint a successor for the unexpired term.

Section 4. Statistician—The Statistician shall procure and keep record of such statistics as may be required by or useful to the Executive Committee.

ARTICLE 6

Section 1. *Committees:* There shall be an Executive Committee, consisting of the Chaiman, Vice-Chairman, Secretary-Treasurer and Statistician, which shall, between regular meetings, carry into effect any and all matters pertaining to the welfare of the Board.

Section 2. There shall also be the following standing committees:

1st. On specific designs of boilers and other pressure vessels and appurtenances and devices used in connection with their safe operation;

2d. On qualification and examination of Inspectors.

Section 3. Such other committees shall be appointed from time to time as may be required.

ARTICLE 7

Section 1. *Removal of Officers:* Any officer or member of any committee may, for just cause, be removed by a majority vote of the membership of this Board at any regular meeting, or special meeting called to consider any grievance or charges, which must be filed in writing, against such offending officer or member of a committee after 30 days' notice.

ARTICLE 8

Section 1. *Meetings:* At least one meeting shall be held annually and special meetings may be held, upon thirty days' notice, at such time and place as may be deemed expedient by the Executive Committee, provided, however, that if such special meeting is called for the purpose of considering any specific design, appurtenance, or device, the expense of such meeting shall be paid by the person or persons making the application.

Section 2. *Quorum:* Seven members shall constitute a quorum for the transaction of business, except that the approval of any specific design, appurtenance or device shall require the 90 per cent affirmative vote of the membership of this Board.

ARTICLE 9

Section 1. *Order of Business:* The order of business at all meetings of this Board shall be as follows:

1. Roll call;
2. Reading of minutes of previous meeting;
3. Reports of standing committees;
4. Reports of special committees;
5. Communications from officers and members;
6. Unfinished business;
7. New business.

ARTICLE 10

Section 1. *Amendments:* This Constitution may be amended by a three-fourths vote of the entire voting membership. Such action must be taken at a regular meeting. A vote by mail can be recorded, provided it is received before or at such meeting.

BY-LAWS

ARTICLE 1

Section 1. *Approval:* Whenever it is desired to have the approval of this Board on a specific design of steam boiler or other pressure vessel, or of any appurtenance or device used in connection with same, the applicant for such approval shall furnish the secretary-treasurer six copies of blueprints, specifications, or other data.

Section 2. The Secretary-Treasurer shall then refer the matter to the standing committee appointed for such purpose. Upon a report of this committee, the applicant will furnish the Secretary-Treasurer a sufficient number of copies of blueprints, specifications, or other data as may be necessary to supply each member of this Board with a copy.

Section 3. The approval of such specific design, appurtenance or device shall require the 90 per cent affirmative vote of the membership of this Board.

Section 4. The Secretary-Treasurer shall keep a complete record to include reasons upon which any application was rejected.

Section 5. Upon receipt of approval by the Board the manufacturer of such specific design, appurtenance or device shall distinctly stamp same with a four-leaf clover design bearing the initials N. B. B. I.

Section 6. The applicant for the approval of such specific design, appurtenance or device shall pay a fee of one hundred dollars to the Secretary-Treasurer at the time of filing application.

ARTICLE 2

Section 1. *Stamp:* Unless otherwise exempted, any steam boiler or other pressure vessel built after July 1, 1921, may be used within the jurisdiction of any member of this Board which has been distinctly stamped with the A.S.M.E. symbol, and the fac simile approved by the National Board of Boiler and Pressure Vessel Inspectors.

Section 2. *Code:* No steam boiler or other pressure vessel may be stamped as specified in Section 1 unless it conforms with the rules formulated by the Boiler Code Committee of the American Society of Mechanical Engineers and has been thoroughly inspected during construction and

upon completion by an inspector who has qualified in accordance with the requirements of Art. 3 of these By-Laws.

Section 3. *Data Reports:* The manufacturer of each steam boiler, stamped as herein provided, shall file with this Board a detailed data report in duplicate, on forms furnished by the Secretary-Treasurer, accompanied by a filing fee of two dollars.

ARTICLE 3

Section 1. *Shop Inspection:* No person shall inspect any steam boiler, or other pressure vessel, during construction and upon completion, and witness the stamping of it with the fac simile approved by the Board, unless he has a certificate of competency as well as a commission authorizing him to do so as hereinafter provided.

Section 2. *Certificates of Competency:* A certificate of competency shall be issued by the political subdivision conducting the examination to any person passing a written examination in accordance with the rules formulated by the National Board of Boiler and Pressure Vessel Inspectors.

Section 3. *Commission:* The holder of a certificate of competency issued as herein provided who desires to make inspections in accordance with the requirements of these By-Laws shall make application to the National Board for a commission authorizing him to do so.

OFFICERS ELECTED

Joseph F. Scott of New Jersey was continued as chairman and C. O. Myers of Ohio as secretary-treasurer. R. L. Hemingway of California was elected vice chairman in place of James Neil, who has left the inspection service for the Bureau of Mines, and William E. Murray of Seattle, Wash., to the newly created office of statistician. Charles E. Gorton, chairman of the American Uniform Boiler Law Society, and F. R. Low, editor of *Power*, were elected honorary members. Votes of thanks were passed in acknowledgment of all that had been done by C. O. Meyers, secretary-treasurer of the National Board, and Charles L. Manney, Clerk of the Ohio Board. The meeting throughout displayed a depth of interest and earnestness of purpose which warrant the belief that the Board will rise to the opportunities before it.

Briquetting Anthracite

In a paper read before the American Society of Heating and Ventilating Engineers at the recent Philadelphia meeting, J. H. Kennedy, of Lykens, Pa., stated that the briquetting industry has been going on in Europe for over fifty years, that it has been developed more rapidly and successfully in Germany than in any other country, and that before the war England was shipping to Italy alone over three million tons of briquets a year.

Briquetting in the United States has been gradually growing, although many ventures into this field have failed. There are three principal reasons for these failures: First, a briquet sold in this country must be as good as, if not better than, coal, while this is not the case in Europe; second, most of the machinery used has been (at least the types) brought from Europe to be used under entirely different circumstances without proper modifications to meet the new conditions; third, poor management and the lack of provision of the necessary capital for a period of experiment which almost invariably is necessary. Nevertheless, the industry is growing, as the net tonnage increased gradually from 66,524 in 1907 to 250,635 in 1914, after which, for reasons with which we are all familiar, the output dropped somewhat for the next year, but recovered until it reached a total in 1918 of 477,235 tons.

A briquet must stand tests to prove that it is (1) hard and tough so as to withstand shipment; (2) able to withstand the attack of the elements, especially water and heat; (3) able to retain its shape while burning; (4) not likely to produce any smoke or undesirable odor while burning. The following materials have been tried as binders under the supervision of the Bureau of Mines: Rosin, pine tar, sulphite liquor, starch, tars, magnesia, magnesia cement, plaster of paris, portland cement, water glass and slag cement.

Mr. Kennedy said that in his own work he used what is commonly called the "water binder," which is made of water 200 gal., Globe pearl starch 140 lb. and asphaltum 35 gal. The binder is mixed with the culm by means of a split-screw conveyor which conveys it to a press consisting simply of two rolls 40 in. in diameter running in opposite directions. In each roll small pockets are cut so as to align exactly as the rolls revolve. The material is fed into the pockets and squeezed into shape between the rolls. A pressure of approximately 10,000 lb. per square inch is required for a good briquet. This varies unless a constant feed is maintained as the face of the rolls must be kept $\frac{1}{32}$ in. apart. From the press the briquets are conveyed to a drier. This particular kind of briquet is intended for household use and shows the following analysis: Moisture, 1.16 per cent; volatile matter, 13.10 per cent; carbon, 75; ash, 10.10; sulphur, 0.64; B.t.u., 14.090; crushing strength, 250 lb. The ash produced by briquets is very fine, almost a powder, and must be handled with care. This is the one undesirable feature so far found, but is easily overcome and far outweighed by its advantages.

Publicity Conference to Be Held in Chicago

A Publicity Conference is to be held at the Congress Hotel, Chicago, on Feb. 25 by the American Association of Engineers. There will be no addresses, but papers will be read by the following men: F. M. Feiker, vice-president of the McGraw-Hill Co., Inc.; John G. D. Mack, state chief engineer of Wisconsin; W. W. DeBerard, Western editor of *Engineering News-Record*, Chicago; William J. H. Strong, head of the Lake Breeze Motor Co., Chicago; C. R. Thomas, in charge of publication of results, Forest Products Laboratory, Madison, Wis.; Ivy L. Lee, publicity director of the Interborough Rapid Transit Co., New York.

Among the subjects that are on the tentative program are the following: "Technical News Service—Is a National Clipping Service Practicable?" "Publicity Possibilities in Magazines and Other Mediums"; "News versus Publicity"; "Will Publicity Pay as a Career?" "How Publicity Helps a Community"; "Effective Methods of Publicity Education on Engineering Publications"; "The Essentials of News Writing"; "How Publicity Helps the Local Society"; "The Engineer as a Public Speaker."

N. E. L. A. Convention To Be Held in Chicago

Chicago has been selected as the meeting place for the forty-fourth convention of the National Electric Light Association. Headquarters will be at the new Drake Hotel, overlooking Lake Michigan, and considered one of the most modern hotels in the United States. The convention will begin its sessions on the morning of May 31 and will end on June 3.

The choice of Chicago was the result of very careful consideration of a number of other available cities, Hot Springs, Arkansas, being looked upon with especial favor. Chicago was finally decided upon, however, because of its accessible location, as it was felt that under present business conditions the delegates woud find it necessary to keep in close touch with their own affairs during the week of the convention.

Welding Committees To Confer

In accordance with an invitation extended by the Council of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers has appointed a committee to confer with the subcommittee of the Boiler Code Committee on Welding of the A. S. M. E. regarding rules now in the Code and in proposing and formulating any revisions or new rules that may be embodied in the Code at the next revision period. The committee so appointed by the A. S. R. E. is as follows: Louis Doelling, New York, N. Y., chairman; E. F. Miller, Cambridge, Mass.; Fred Ophuls, New York City; Norman M. Small, Waynesboro, Pa.; and Harry Sloan, Milwaukee, Wis.

Injection and Combustion of Fuel Oil in Diesel Engines*

By C. J. Hawkes
Eng.-Com., British Navy

The injection of fuel oil in Diesel engines is of the utmost importance, especially in the case of engines of comparatively high speed. The general method of injecting fuel oil into the Diesel cylinder is by the use of compressed air, but considerable advance has been made in the solid-injection system.

The single-cylinder four-stroke-cycle engine used in the tests had an aluminum piston and developed 100 hp. at 380 r.p.m., the cylinder being 14.5 in. in diameter by 15 in. stroke. The solid-injection fuel valve was of the direct-lift type and was actuated by a cam on the camshaft.

Experiments were carried out with the object of ascertaining the effect of varying the number and size of the holes in the sprayer plate. Tests were run with a sprayer having five holes 0.019 in. in diameter and with holes of smaller diameter and with varying oil pressures. The results appear in the table.

Design of Fuel Valve and Fuel Pump as Affecting Combustion

The success of the solid-injection engine in service, from the point of view of smokeless combustion, depends very largely on the design of the fuel valve and fuel pump. It is imperative that every precaution be taken to insure the thorough filtration of the oil. It was found that even a little dirt would stop up one or more sprayer holes.

In the direct-lift type of solid-injection fuel valve the spray is obtained by forcing oil at a high velocity through the sprayer holes. When the needle valve starts to lift this pressure due to wiredrawing is less than required. The spray, as a consequence, is composed of fairly large drops both at the beginning and at the ending of the injection period. The defects of this type of valve are more marked as the speed of the engine is decreased.

TESTS WITH SOLID-INJECTION DIESEL

			— Fuel Oil —		—— Spray Valve ——			
R.P.M.	B.h.p.	Opening Fuel Valve Before d.c. Degrees	Lb. per B.h.p. Hour	Oil Line Pressure	No. of Holes	Dia. of Holes	Roller Clearance	Cylinder Compression
380.0	100.1	20.0	0.45	4,000	5	0.019	0.030	460
381.5	101.0	10.5	0.42	4,200	5	0.016	0.072	460
377.5	99.4	11.5	0.42	4,500	5	0.016	0.095	460
380.0	100.0	19.0	0.47	4,300	5	0.016	0.003	485
382.9	101.0	23.0	0.43	3,400	5	0.016	0.003	380
380.3	100.3	12.0	0.42	5,600	5	0.016	0.003	490
380.3	100.2	8.0	0.46	5,600	5	0.016	0.100	490
378.4	99.8	8.5	0.47	5,700	5	0.016	0.100	490

An automatic type of valve was designed whereby the pump pressure acting on an enlarged section of the needle valve lifted the needle. The closure was accomplished by means of a spring. Because of the shape of the combustion space a high spray angle was necessary. The engine failed to deliver its rated horsepower although at low speeds and low loads the action was excellent. A better-designed valve of the automatic type would undoubtedly give better results.

Experiments were carried out with the object of ascertaining whether improved results would be obtained with the solid-injection system by increased turbulence, due to increasing the velocity of the air through the induction valve. These experiments indicated that there was no improvement due to increased turbulence; in fact, the fuel consumption was slightly increased and the exhaust was slightly shaded. On the face of it, it would appear that turbulence would assist combustion in the case of the Diesel engine—but it will be seen that a high degree of turbulence might have a harmful effect by distorting the spray and causing a portion of it to be brought in contact with the comparatively cool walls or cover of the engine before the oil globules had completely vaporized. This action would produce a smoky exhaust. It is very essential that a fuel spray should not strike a cool surface, and as a high degree of turbulence would have a tendency to bring this about it is considered that turbulence is not so desirable in the Diesel engine as it undoubtedly is in the explosion engine. The turbulence referred to is, of course, that due to high air speeds through the induction valve and not to the use of blast air in air-injection engines. Blast air splits up and distributes the fuel oil in the combustion space, but it acts symmetrically about the center line of the sprays and its direction of action is under control (depending on the position, size and shape of the holes in the distributor or flame plate); consequently it is much less likely to drive a portion of the fuel on to the cool walls of the liner and cover.

*Extract from paper read before the N. E. Coast Institute of Engineers.

Air Injection Now Principally Used

There is no doubt that solid injection has much to recommend it, so long as it is in every way satisfactory in service. With its adoption it is not necessary to make provision for an air compressor for supplying blast air—and the high-pressure compressor, as is well known, has in some instances been a continual source of trouble. Air injection is, however, principally used today, and it seems fair to presume, therefore, that many manufacturers have largely, if not entirely, overcome their compressor troubles. As far as present experience is concerned it is considered that the greater variety of fuel oil can be used more satisfactorily with with air injection than with solid injection. In the case of oils experimented with at the laboratory it has been found that up to about 100 lb. mean indicated pressure the fuel consumption is approximately the same with solid injection as with air injection, at the same power and speed, after taking into account the power required to drive the injection compressor. This means that while the consumption per brake horsepower is the same with both systems, the consumption per indicated horsepower is less with the air-injection engine than with the solid-injection engine; that is, the combustion of the fuel oil in the air-injection engine is slightly better than in the solid-injection engine. This difference is no doubt largely due to the better and more rapid distribution of the fuel-oil mist in the compression space, which naturally follows the use of air for injection purposes, as the sprays have more energy, and the air when it expands in the combustion space carries the fuel-oil mist with it. Owing to the cooling effect of the injection air, however, a higher compression is necessary in the air-injection engine than in the solid-injection engine, for the same fuel oil. It is also found that the solid-injection engine starts more readily from the cold condition than the air-injection engine, although in this connection much depends on the compression ratio and the type of sprayer employed.

At mean indicated pressures at and above 110 lb. per sq.in. in the experimental engine running at 380 r.p.m. smokeless combustion could not be satisfactorily obtained with the solid-injection system, and as it was desirable that higher mean indicated pressures should be developed it was decided to experiment with the air-injection system.

In the ordinary air-injection valve the fuel is forced into the fuel-valve casing against the pressure of the injection air, but no advantage is derived from the pressure to which the fuel oil is subjected. In the modified valve tested on the engine the oil is sprayed in the manner common to solid-injection systems, but inside the cylinder it meets a jet or jets of air, so that the distribution is thereby improved. It was hoped that by the use of such a valve a smaller quantity of blast air would be required than is necessary with the ordinary air-injection valve. Further, in the event of the air compressor failing the engine would be able to run at a slightly lower power satisfactorily on solid injection alone. Various valves were tried, based on this principle, both with the air jets surrounding the fuel jets and also with the fuel jets surrounding the air jets.

It has so far been found that with such a fuel valve smokeless combustion can be obtained with a mean indicated pressure of 130 lb. per sq.in. The consumption of blast air is slightly less than with the ordinary air-injection valve. The fuel consumption was 0.41 lb. per brake horsepower; this, however, does not account for the compressor demand, since this was driven by an electric motor. This valve has some advantages over the usual air-injection fuel valve but is somewhat complicated.

Washington News

Calder Bill Opposed in Its Present Form—Fuel-Inspection Plan Explained—Senate Fails to Aid Power Commission—Muscle Shoals Development Debated

By Paul Wooton
Washington Correspondent

The Committee on Manufactures of the Senate, which has conducted extensive hearings on the Calder coal bill, is expected to report the proposed law to the Senate in a much modified form. The bill as it will be reported probably will be confined to the fact-finding provisions which would make obligatory pertinent returns from operators and others engaged in the coal business.

Great opposition developed to the form of control outlined in the original Calder bill. Not only was it opposed by the operators, the wholesalers and the retailers, but by organized labor as well and by the Chamber of Commerce of the United States.

The committee very evidently was impressed by the opinions of Dr. George Otis Smith, the director of the United States Geological Survey, who was recalled to the stand. He emphasized that he is as much opposed to the nationalization of the coal mines as he is to their being considered the absolute private property of land owners and mine operators. He believes, however, that there should be some control of the industry and that such regulation is justified under the general principles of the common law, as well as under the constitution.

Bureau of Mines Fuel Inspection Plan

In considering legislation looking to the protection of consumers of coal the Calder committee and the Committee on Manufactures of the United States Senate are carefully studying the fuel-inspection plan that has been brought forward by the Bureau of Mines. In this connection O. P. Hood, the chief mechanical engineer of the Bureau of Mines, has authorized an explanation from which the following is taken.

The Bureau of Mines proposes a fuel-inspection system which contemplates as a salient feature advice to the public as to the quality of coal as shipped. The only force depended upon to produce results is a public statement of the facts, rather than the arbitrary police power needed in time of war. For this purpose the machinery for accurate sampling of full carload lots by an impartial organization is necessary. The Government now possesses facilities for analyses and publication.

It is proposed that each mining company set its own standard of quality, consistent with the particular vein, preparation, and market which the business affords, and that the Government shall publish such standard and certify as to whether such standard is being maintained by the mining companies. Such work would not replace inspection by the mining companies. It would not certify as to the quality of each and every shipment, but it would inspect and sample at irregular intervals a sufficient number of cars of coal as shipped to indicate whether the declared standard of the mining company was being maintained.

Mines entering the system would be privileged to advertise that their product was from a mine whose standard of preparation was certified by the Government. In case coal shipments were sub-standard the mine would be advised of the fact. If the condition continued the facts would be given publicity and the mine, to retain a place as a certified mine, would be required to declare a new and different standard and one which its product could meet.

Mines entering this system would agree to allow shipments to be sampled en route at sampling stations and stand any added expense of transportation and handling incident thereto. All analyses would be published from time to time giving accurate information about American coals. Mines need not come into this system, but there would be manifest advantages in being on a Government approved list which would gradually increase the number using the service.

It is believed that some measure of this kind, akin to our meat and wheat inspection systems, fits the public temper at the present time and would be a real help in fuel conservation without going too far in governmental contact with business.

Work of the Federal Power Commission has been crippled ever since the enactment of the Water-Power Act because the act does not authorize employment of personnel by the commission. With the exception of the executive secretary and the chief engineer all employees must be borrowed from the staffs of the War, Agriculture and Interior Departments. Now the Senate has approved an amendment to the Sundry Civil bill which promises to increase rather than eliminate the difficulties of carrying into effect the provisions of the Water-Power Act. The Senate amendment provides fifteen statutory positions, including that of chief accountant, but prescribes such limited salaries as to make it impossible to employ any but the most amateur services.

The chief accountant of the commission now receives $7,500 and is on the payroll of the War Department. The Senate amendment provides that the chief accountant is to receive $3,000. It may be necessary to drop the position, discontinue the work and allow the money to revert to the Treasury, although it is barely possible that the War Department might consent to a change of title on the part of the chief accountant and continue the same salary.

There are those who think that there is a deliberate move on foot to nullify the Water-Power Act through denial of the possibility of its administration.

Development Work at Muscle Shoals

Those who favor a continuance of the development work being done by the Government at Muscle Shoals on the Tennessee River are much encouraged by the action of the Senate on Feb. 5 in upholding the Committee on Appropriations, which had inserted in the Sundry Civil bill an appropriation of $10,000,000 for the Wilson dam. The amendment was strongly opposed on the floor of the Senate, but was retained in the bill by a decisive vote of 36 to 27. The Committee on Appropriations of the House of Representatives declined, however, to approve this $10,000,000 item. An effort to embody it in the bill on the floor of the House failed by a small margin. There is some doubt whether the item can be retained in the bill in conference.

Senator Smoot of Utah, who voted against the amendment in committee and opposed it on the floor, declared it to be his belief that it is unwise for Congress at this time to appropriate $10,000,000 for the Muscle Shoals project. "So far as I am concerned," he said, "I would rather take the loss that may come to the Government than to put another cent into the project." He stated that some $12,000,000 has been expended on the dam, but that the United States could dispose of its rights and property for $7,000,000 or $8,000,000.

Senator Underwood took exception to the statement and said that expenditures are continuing each day with every prospect that the full $17,000,000 at the disposal of the engineers will have been expended or obligated before any action is taken to discontinue the work. If Congress refuses to carry on the existing work, he declared, the next big rise of water in the Tennessee River will wash the Government's $17,000,000 downstream.

Senator Underwood pointed out that the Army engineers estimate that it will cost $28,000,000 more to complete the dam, from which 550,000 hp. can ultimately be developed. He said, however, that he is willing to accept the estimate of Colonel Hugh Cooper that it will take $33,000,000 more. He referred to Colonel Cooper as "the ablest hydraulic engineer in the United States, if not in the world," and cited him as authority for the statement that the United States could expect to realize 5 per cent on its investment in the Muscle Shoals project and then have a spread of $10,000,000 to go to someone else.

Water-Power Applications

Applications received by the Federal Power Commission during the week ended Feb. 5 follow: Marcus Pluth, 424 Wilcox Building, Los Angeles, two diversion dams, conduit, power house and transmission line, White Water River, California; E. N. Tunin, Keechelus Inn, Hyak, Wash., conduit and power house, Wolf Creek, Washington; Harrison Albright, Laughling Building, Los Angeles, dams, conduits, power houses and transmisison lines in San Bernardino and Riverside counties, California.

Discuss Waterwheels and Relay Plants

The third of a series of joint meetings of the Boston sections of the Mechanical, Electrical and Civil Engineers to discuss power development in New England, was held at the Boston City Club on Monday evening Feb. 7. The papers of the evening were: "Recent Waterwheel Developments and settings," by W. M. White of Allis-Chalmers Mfg. Co., and "Designs of the Steam Power Station for Hydraulic Relay," by E. B. Powell of Stone & Webster.[1]

Mr. White prefaced his remarks by pointing out that the present hydro-electric station may, as a rule, be considered a unit just as the individual wheel was considered a unit a few years ago; that is, formerly in designing a hydro-electric plant there were limitations imposed by the load required in the given locality and overdevelopment often resulted. Now the plant is usually a part of a system and the problem is simplified in so far as economic development is concerned.

Referring to the design of the wheel itself, Mr. White emphasized the importance of a low velocity in the spiral casing as high velocities lead to friction losses. High efficiencies involve unrestricted flow from the forebay to the tips of the guide vanes. The great loss, he said, is in the water discharged from the runner. In the ordinary designs from 4 to 20 per cent of the energy of the water is discharged from the runner. This should be conserved by maintaining a suction or vacuum by means of a proper regaining device to transform the velocity back into suction head.

Mr. White preferred placing the governor-control valve on top of the guide casing. This not only makes for decreased cost but by employing direct-connected flyballs troubles incident to the driving gear and jumping of the flyballs is eliminated. Individual pressure oiling systems on account of their simplicity were also recommended. The speaker displayed a number of slides showing some of the latest designs of waterwheel settings. The pictures also illustrated the latest developments on the Kerckhoff system and that of the Great Western Power Co. in California.

Steam Relay Stations

Mr. Powell divided the steam relay station into two general types—one for flow or head deficiency make-up and the other for emergency reserve. The design, while broadly determined by the usual factors, such as location, power market, water and fuel supplies, fuel cost, etc., is in general, on account of the commonly low load factor, less dependent upon considerations of operating economy. On the other hand, character of load and dependability of delivered hydraulic power are factors of prime importance. The speaker further divided the design into four classes as follows and took up in detail the requirements for each type:

Minimum Flow Development—Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow only slightly, and for brief periods in the year, below corresponding load requirements. Reserve provided in hydraulic station.

Medium Flow Development—Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow below load requirements for considerable period, 40 per cent or more of the year. Reserve provided in hydraulic station.

Continual Relay Development—Available hydraulic capacity slightly below system load requirements throughout greater part of the year.

Supplemental Development — Hydraulic development merely an adjunct to the steam power station, which carries the bulk of the load.

Discussion

In discussing Mr. White's paper Professor Allen of Worcester Polytechnic Institute called attention to the deplorable condition of many of the small water power developments in New England. In testing many of these plants he had found obstructions of all sorts in the intakes and operation at partial gate openings when full capacity was desired; larger wheels that had replaced smaller wheels without the setting being altered and a variety of other conditions all tending to decrease the efficiency of the units. In the majority of these plants he found no attempt to make periodic inspection. In the opinion of the speaker now was the time, with a decrease in industrial demand, to give attention to these waterwheels and improve their operating conditions in general.

R. J. S. Pigott in discussing Mr. Powell's paper emphasized the importance of reliability in stand-by stations. Such a station should not be shut down for any length of time as this will have a bad influence on the morale of the operating force and prevent maximum service out of the station when it is most needed. Referring to the pressures and temperatures that should be employed he believed that present practice was about up to the limit consistent with satisfactory operation. When we get above 750 deg. the slight gain in economy is likely to be offset by troubles with valves and pipe joints. Valves will not stay tight under these high temperatures if the operating conditions are such that they are allowed to cool off for certain periods of the day. He favored a one-metal valve for high pressure and superheat.

In steam relay stations there was no object in employing a higher ratio of boiler heating surface to grate surface than 50 to 1. With a large stoker and forced capacity of 75 to 100 lb. of coal per sq.ft. of grate surface per hour sufficient overload could be attained. For such service it is undesirable to put in a turbine having its best water rate at a load near its maximum capacity. Instead it is better to use a turbine having a rising load characteristic, connected to a generator having a capacity double that of the turbine's most economical load. A turbine with its relay valve further down the stages will have a greater capacity although less efficient at overload.

[1]Abstracts of both these papers will be published in *Power*.

Heat, Light and Power for New York City

On Wednesday evening Feb. 9, in the auditorium of the Engineering Societies Building, the New York sections of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers met and discussed the problems involved in a supply of heat, light and power for the Metropolitan District of New York. The chief speaker was William Barclay Parsons, who presented a paper in which he gave a general survey of the problem. He pointed out that the capacity of central stations in New York State including the Metropolitan District of New York City had increased from 1,470,000 hp. in 1910 to 3,250,000 hp. in 1919, or approximately 120 per cent in nine years. The installed capacity in 1930 will probably be around 6,700,000 hp. for this territory, of which 4,500,000 hp. will be required in the Metropolitan District, involving an investment of $350,000,000. After a review of the water power possibilities in the state, the conclusion is drawn that much of the power installation that can be expected in the near future will be of the steam-electric type with the attendant high cost of operation. An abstract of this paper will appear in an early issue of *Power*, along with abstracts from the discussion presented by L. W. Lieb and W. S. Murray.

In discussing the paper, Farley Osgood pointed out that with a 50 per cent load factor a kilowatt-hour could be produced in central stations on an average of 1.5 lb. of coal and with 75 per cent load factor on 1.3 lb. The load on central stations has been increasing at the rate of 10 per cent a year; if the companies could get the capital to finance extensions this load would increase at 15 per cent a year at least. The cost of everything entering into the production of power has been increasing, but the efficiency of the steam turbine has also been increasing, and for this reason more than any other it has been possible to sell power at the present low figure. Only by the most careful co-ordination of all the factors in large power systems to obtain the highest economy can the price of power be maintained at the present figures.

L. W. Lieb advised going carefully on the problem of increasing load factor by interconnecting different systems, since many power companies had been working their load factor up to about as high as it might be expected under present conditions. The greatest possibilities in this direc-

tion are in the development of the electrical vehicle. If electrical vehicles were in use on a large scale, the charging at off-peak periods would do a great deal to improve load factor. With regard to co-operation between isolated plants and central stations, the speaker said that at first thought this looks attractive, but an investigation shows that little was to be gained by such interconnection, since at the present time there were summer peak loads just as high as the winter peaks.

Frank Smith was of the opinion that the proposed restrictions placed by the Federal Power Commission were such as to make it difficult to finance water-power developments.

George Otis Smith called attention to the condition in the coal field of the eastern section of the country. Here is located only one-fifth of the coal resources of the country, but at the present time 75 per cent of the coal mined comes from this district. The speaker characterized the trouble with the coal industry as low load factor. In discussing the location of sources of power compared with the location of industrial zones, he said the center of gravity of our coal resources was in central Nebraska, while the center of production was in central Ohio. Oil resources had their center of gravity in eastern Colorado, for water power the center of gravity is in Wyoming, while the center of power demand is located at Marion, Ohio (laughter). Mr. Smith claimed that an adequate supply of cheap power is the most effective means of protecting American industries against foreign competition.

H. E. Skougor touched on the possibilities of developing power from the tide and called attention to the proposition under consideration in England at the present time to develop power at the mouth of the River Severn. He said the gas industry had been at a standstill for the last fifteen years, although it should have been enjoying just the same healthy progressiveness as the electrical industry. The speaker recommended discontinuing the use of gas for lighting purposes so that the use of gas oil could be eliminated and the cost of gas production decreased. It was his opinion that the future would see super-fuel gas stations, utilizing the products of coal that are now wasted and supplying gas for heating purposes.

A. W. Stark said that the importance of the gas industry is not appreciated, but that within 20 miles radius of New York City as high as 300,000,000 cu.ft. of gas per day is used, and that the yearly consumption amounts to 60,000,000,000 cu.ft. requiring 2,000,000 tons of coal and 4,000,000 bbl. of oil. In five years the yearly consumption will probably increase to 100,000,000,000 cu.ft. On one gas company's system in Greater New York, change in outside temperature of 20 deg. led to an increase of 30,000,000 cu.ft. consumption in one day. Stand-by equipment to meet this demand represents an investment of $8,000,000.

F. O. Blackwell expressed the opinion that there was a lot of coal near New York that was not salable, and that plants could be built at the mines and power enough developed to supply the industries in these sections and still have a surplus left to be transmitted to New York City. The speaker was also of the opinion that there is considerable water power that could be developed within economical transmission distance of New York City. This is chiefly on the Delaware River and in the Adirondacks. The speaker said he was doubtful if any power beyond the Adirondacks would ever be brought to New York. Niagara Falls power at high load factor is very cheap, but at low load factor its cost is high. Mr. Blackwell suggested as a means of increasing load factor the pumping of water from the Hudson River up into reservoirs on the Palisades during the off-peak periods, and using this water during the peak load to drive hydro-electric units. The design of some types of water-wheels is becoming so much like a pump that probably in the near future machines can be constructed which may be used as motor-driven pumps or as hydro-electric generating units.

W. S. Murray told of some of the work of the Super-power Survey and said that water power would represent only 10 per cent of the total power demand in the Super-power zone in 1930. This demand in 1919 was 27,000,000,000 kw.-hr.; by 1930 it will increase to 50,000,000,000. However, owing to a more efficient production of energy by the Super-power System, the coal burned in 1930 will be only 14 per cent in excess of that in 1920. The actual ratio of coal consumption on railway with electric locomotives over that of the steam locomotives amounted to as high as 1 to 6.

George Gibbs questioned the estimated 10 per cent yearly increase in power demand during the next ten years in the Metropolitan District although the past nine years has shown an increase of 13 per cent. The latter was due to electrification of trunk-line railway and other influence, which may not be so pronounced during the next ten years. Mr. Gibbs also questioned the advisability of offering cheap power to attract manufacturing to the Metropolitan District, when the present congestion and railway requirement demand a change.

Big Delaware River Development Under Way

A plan to develop the water power of the Delaware River has been filed with the Federal Power Commission calling for the construction of four dams, at or near Belvedere, Bushkill, Shohola and Butler's Rift, with an average head of 80 ft. The total power capacity of these four dams is estimated at about 500,000 kw. at normal high water. In addition, a steam-power plant with a capacity of 100,000 kw. will be erected somewhere in New Jersey in order to supplement the hydro-plants during seasons of low water.

The power will be sold wholesale in large blocks in New Jersey, eastern Pennsylvania and southern New York, though it is believed at this time that New Jersey will take the major part of the total capacity.

If present plans are carried out, the steam power plant and two of the hydro plants will be in operation by Jan. 1, 1923. The total cost of the project is estimated at about $200,000,000, and it is being sponsored by Paul T. Brady, of the Westinghouse Electric and Manufacturing Co. Mr. Brady's associates in the enterprise are Duncan, Young & Co., the L. B. Stillwell Engineering Co., and the engineers of the Westinghouse Electric and Manufacturing Company.

Personals

J. W. Wilt, formerly purchasing agent for R. H. Beaumont Co., Philadelphia, Pa., has resigned to enter into business as manufacturers' agent, with headquarters at 461 North Second St., Philadelphia, Pa.

W. J. Davis, Jr., who has been Pacific Coast engineer for the General Electric Co., is now in the railway and traction engineering department of that company at Schenectady, N. Y.

W. A. Dunkley, previously a gas engineer on the staff of the Illinois State Geological Survey, has been put in charge of the Urbana Station of the United States Bureau of Mines. Mr. Dunkley will continue the work on fuels processing with which he has been associated for some years past.

W. W. Odell, who has been conducting fuels carbonization investigation at the Urbana Station of the Bureau of Mines, has been transferred to the Washington offices, where he will assist O. P. Hood, chief mechanical engineer of the bureau, in further prosecution of lignite carbonization studies.

Society Affairs

Detroit Section, A. S. M. E., will meet Feb. 18 to hear L. P. Alford discuss "The Engineer in Industrial Readjustment."

The American Boiler Manufacturers Association will hold its winter meeting on Feb. 22 at the Hollenden Hotel, Cleveland, Ohio.

The Society of Automotive Engineers will hold a meeting at the University Club, Buffalo, N. Y., on Feb. 23. Ferdinand Jehle, of the Aluminum Manufacturing Corp., will speak on "The Piston Temperature in Internal-Combustion Engines."

The American Society of Safety Engineers will hold a meeting at the Engineering Societies Building, New York City, on Feb. 25, at which papers will be presented on the general subject of "Safety to Life in Ship Construction and Operation."

The American Society for Steel Treating will hold a meeting at the Engineers' Club, Philadelphia, Feb. 16 at 8:15 p.m. Lieutenant A. E. White, the national president, and other prominent men will make addresses. A dinner will precede the meeting.

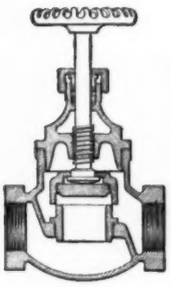
The Construction Division Association will hold a meeting at the American Hotel, Chicago, Ill., on Feb. 25 and 26, which will be in the nature of a reunion of those who were identified with the Construction Division of the Army during the war. The annual banquet will be held February 26.

The American Society of Mechanical Engineers is to hold its spring meeting on May 23-26 at the Congress Hotel, Chicago. Sessions are planned to be held by the professional sections on aëronautics, fuel, management, material handling, machine shop, power, foreign products and railroads.

Condensed-Clipping Index of Equipment

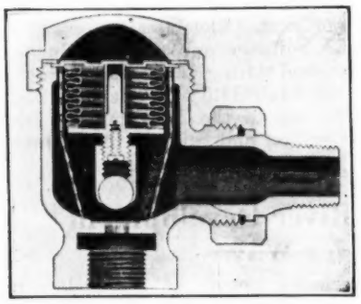
Patented Aug. 20, 1918

Valve, B & O Protected Seat
Protected Seat Valve Co., Peoples Bank Building, Pittsburgh, Pa.
'Power," Dec. 21, 1920.



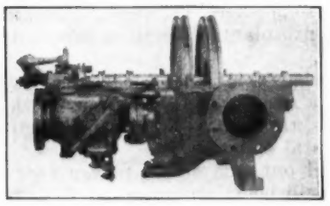
The seat of this valve is protected from the flow of liquid or gases before the valve disc seat. This is because the sleeve telescopes when the valve is being closed, which reduces the velocity of the flow to a minimum. When opening, the valve disc is raised above the zone of circulation before the telescoping sleeve is disengaged. The distance between the ground seat is several times greater than the area of the opening when the sleeve is slightly disengaged. The seat and disc are easily removed. Pressure may be applied from either side of the seat.

Trap, New Sarco Radiator
The Sarco Co., Inc., New York City
"Power," 1921.



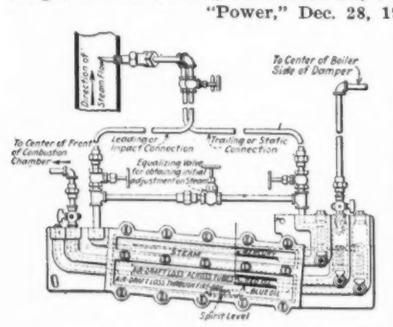
This new valve for radiators and steam-heating service has a heavy brass body, and the expansion element is a spiral bellows. The valve head is a ball freely turning in a socket. A strainer of ample capacity is provided in the valve casing. This trap can be used for any vacuum or for low pressure up to 20 pounds.

Turbine, New Steam for Mechanical Service
General Electric Co., Schenectady, N. Y.
"Power," Dec. 28, 1920.



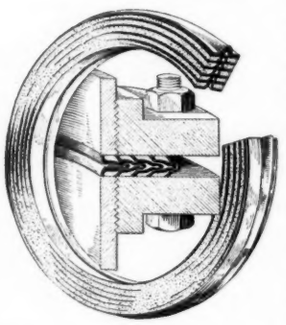
This turbine is designed for either one, two or three stages for driving centrifugal pumps, blowers, etc., and operates at steam pressures of from 50 to 300 lb., with or without superheat and non-condensing or condensing. It is designed for an output of from 10 to 400 hp. at 1,000 to 5,000 r.p.m. The upper half of the wheel casing and bearings are removable. The casing is supported on three feet which does away with twisting strains. Steam passes from the steam chest to the first-stage nozzles, which direct the flow into the buckets on the wheel. For certain purposes some of these nozzles are opened or closed as required by hand valves placed in the steam chest.

Guide, "Producto" Combustion
Progress Products Co., 1313 Race St., Philadelphia, Pa.
"Power," Dec. 28, 1920.


To Center of Boiler Side of Damper
To Center of Front of Combustion Chamber
Leading or Impact Connection
Trailing or Static Connection
Equalizing Line for obtaining initial adjustment on Steam
STEAM
AIR
Spirit Level

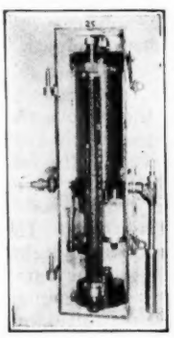
This instrument indicates when the furnace fires are too thick or too thin and when there are holes in the fire bed. It combines the advantages of a steam-flow meter and a multiple differential draft gage. The instrument involves the lining up of steam-flow and air-flow liquid levels by a given steam load with the boiler operating efficiently. When efficient steaming conditions are maintained, the alignment of the liquid levels is maintained line and line in their respective gages and the liquid that is out of line indicates what is wrong.

Gasket, Flexitallic Boiler and Flange
Flexitallic Gasket Co., Camden, N. J.
"Power," Dec. 28, 1920.



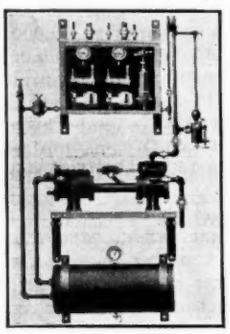
This gasket consists of a cushion of waterproof asbestos spirally wound to conform with metal strips and put in place under pressure. The metal strips are wound in a spiral dovetail shape starting on the inside and working out ply by ply to the size of gasket required, thus making it practically impossible to blow out and at the same time creating great resiliency. As the metal is on edge and at right angles to the line of pressure, the gasket does not adhere to the fittings and takes care of expansion, contraction and vibration. This gasket is suitable for use on boiler manholes and tube caps for water-tube boilers or on any joint where it is difficult to make the gasket hold tight.

Indicator, W. R. Combustion
Chadburn (Ship) Telegraph Company of America, Inc., Troy, N. Y. "Power," Dec. 21, 1920.



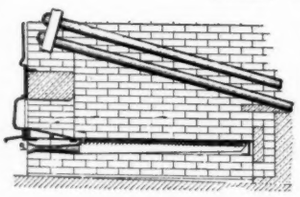
In this CO_2 indicator there are no liquid chemical solutions used, but in their place a dry reagent cartridge in a porous vessel that is within a metal cylinder. The bottom end of the porous vessel connects with a tank of colored water and a gage glass. The water is subjected to the pressure of the flue gas streaming into the instrument and surrounding the outer surface of the vessel. A variable pressure occurs within the porous vessel, due to the affinity of the dry chemical composition of the cartridge for the CO_2 contents of the flue gas, which is absorbed by the dry cartridge. By this action the pressure within the porous vessel becomes lighter and the colored liquid in the gage glass rises accordingly. A definite percentage of CO_2 in the flue gas passing over the porous vessel causes a definite rise of the water in the gage glass, therefore the water color indication is so calibrated that direct readings of CO_2 percentages are obtained.

Combustion Control, Gray System of Automatics
Automatic Fuel Saving Co., of Philadelphia and Chicago
"Power," Dec. 28, 1920.



In this device the control of the three elements of regulation, boiler damper, air supply and stoker speed, is obtained by means of diaphragms operated by compressed air, the necessary variation in the diaphragm air pressure being controlled by two valveless leak ports. All these factors are co-ordinated so that simultaneous adjustment is made of air, coal and damper positions. The outstanding feature is the maintenance of the over-fire vacuum by the variation of the air pressure under the grates. The steam-pressure control is operated by the variation of steam pressure in the header. As the pressure in the diaphragms is lessened, the boiler damper is opened a certain degree and the stoker is speeded up, the variation in either depending on the steam-pressure drop.

Furnace "Turbine" Boiler
Electrical Review, London
"Power," Dec. 14, 1920



This boiler furnace consists of several troughs, the number varying with the width of the furnace, rounded at the bottom and measuring about 5 in. across their mouths. They are disposed longitudinally in the furnace. Within the mouths of the troughs are placed fire-bar members, so that each trough has from 36 to 48 of these fire-bar castings. Between each pair of castings a $\frac{1}{8}$-in.width air slot is left. The rear face of the blade of each casting is at an angle of 45 deg. to the surface of the grate. Air is brought to the trough by a steam jet. This type of furnace enables fine fuel to be burned, because the inclined surfaces tend to prevent the fuel from falling through the slots between the fire-bar members. As the air pressure in the troughs depends on the pressure of steam delivered to the jets, the air pressure below the fire-bars can be regulated over a considerable range so that a wide variety of fuel can be burned in the furnace. This furnace is readily fitted to any type of boiler.

Clip, paste on 3 x 5-in. cards and file as desired

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Govt. Price	Dec. 27, 1920	Jan. 24, 1921	Feb. 1, 1921
Pocahontas	Columbus	$2.35	$5.63	$4.00	$4.00
Clearfield	Boston	2.95	3.75	2.85	2.75
Somerset,	Boston,	2.95	4.50	3.65	3.55
Pittsburgh,	Pittsburgh	2.35	2.75	2.50	2.50
Kanawha,	Columbus	2.70	2.90	2.90	2.40
Hocking,	Columbus	2.50	2.50	2.50	2.35
Pittsburgh,	Cleveland	2.35	3.00	2.60	2.50
Franklin, Ill.,	Chicago	2.35	3.40	2.75	2.75
Central, Ill.,	Chicago	2.35	2.50	2.35	2.15
Ind. 4th vein,	Chicago	2.35	3.25	2.50	2.15
Standard,	St. Louis	2.55	....	2.50	2.00
West Ky.,	Louisville	2.35	2.75	2.35	2.50
Big Seam,	Birmingham	2.45	3.25	3.25	3.00
S. E. Ky.,	Lousville	3.00	3.40	2.70	2.70

DIESEL FUEL OIL

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3½@4½ c. per gal.

Cincinnati—In 8,000-gal. tank cars; 26@28 deg., 9½ c. per gal., 30@34 deg., 10c.

Cleveland—24@30 deg. fuel oil, group 3, $0.85 per bbl.; gas oil, group 3, 4c. per gal. No market for boiler oil.

Philadelphia—26@28 deg. fuel oil, 8½c. per gal.; 30@34 deg. gas oil, 10½c.; 16@20 deg. boiler oil, 6c.

St. Louis—Base plus freight; group 3 24@26 deg., $1.10@$1.25 per bbl.; 26@28 deg., $1.20@$1.35; 28@30 deg., $1.30@$1.45; 30@32 deg.,$1.40@$1.55; 32@34 deg., $1.50@$1.65. No market for 16@20 deg. Baumé boiler oil.

New Construction

N. H., Exeter—Phillips-Exeter Academy plans to build a 2 story infirmary on the campus. About $250,000.

Mass., East Boston (Boston)—A. DeStefano, 8 Everett St., plans to build an 8 story mercantile building on Orleans St. About $250,000.

Mass., Wellesley—Wellesley College plans to build a students' alumnae building and a residence hall. About $300,000 each. Architect not selected.

Mass., Worcester — The W. H. Sawyer Bldg. Trust plans to build an office building on Main St. About $300,000. Architect not selected.

R. I., Newport—The Bd. Educ. will receive bids until Feb. 24 for a 3 story, 105 x 150 ft. high school on Central St. A steam heating system will be installed in same. About $500,000. B. H. Seabury, 21 Besse Pl., Archt.

Conn., Bridgeport—The Bd. Educ. plans to construct a 3 story, brick, steal and reinforced concrete high school. About $1,000,000. Architect not selected.

Conn., Bristol—The town, c/o S. P. Colt, Chn. of the Memorial School Com., is having plans prepared by Clarke & Howe, Archts., 1304 Turks Head Bldg., Providence, R. I., for a 3 story junior high school on the Perry plot. About $300,000.

Conn., Hartford—The High School Bldg. Comn. plans to construct a 3 or 4 story fireproof high school, on Greenfield and Ridgefield Sts. and Blue Hills Ave. About $1,500,000. W. H. Scoville, Chn. L. W. Robinson, 42 Church St., New Haven, Consulting Archt.

Conn., New Haven — Grace Hospital Assn., 1418 Chapel St., plans to construct a brick and steel addition to the present building on Chapel St. About $750,000. Architect not announced.

Conn., New Haven — Mendel & Freedman, 712 Chapel St., plans to construct a brick, steel and reinforced concrete department store on Chapel St. About $300,000. R. W. Foote, 185 Church St., Archt.

N. Y., Brooklyn — H. C. Bohack, 1291 Bway., New York City, is having sketches prepared for a warehouse, including a steam heating system, on Wyckoff Ave. and Washington Pl., here. About $750,000. Architect not announced.

N. Y., Brooklyn—The Homestead Bank of East New York, 141 Pennsylvania Ave., is having plans prepared for a 2 story, 50 x 120 ft. bank. About $300,000. Holmes & Winslow, 134 East 44th St., New York City, Archts. and Engrs.

N. Y., Morris Park, L. I.—The Bd. Educ., 500 5th Ave., New York City, will soon award the contract for a school, including a steam heating system, on 24th St. and Curtis Ave., here. About $500,000. C. B. J. Snyder, 28th Floor, Municipal Bldg., New York City, Archt.

N. Y., New York—The Dept. of Educ., 500 Park Ave., will soon award the contract for a school on Burnside Ave. (Bronx Boro.). About $500,000. C. B. J. Snyder, 28th Floor, Municipal Bldg., Archt. and Engr.

N. Y., New York—A. Lewisohn & Son, 61 Bway., have awarded the contract for a 7 story store and office building at 13 East 42d St., to J. G. Siegel, 17 East 49th St. A steam heating system will be installed in same. About $500,000.

N. Y., New York — O. H. Bruen of the Washington Laboratories, c/o Rouse & Goldstone, Archts., 512 5th Ave., is having sketches prepared for an 8 story, 100 x 100 ft. sanitarium, including a steam heating system, on Ave. A near 68th St. About $500,000.

N. Y., Perrysburg—The city is having plans prepared by H. L. Beck, City Archt., for a group of buildings to be used as a tuberculosis hospital. About $800,000.

N. Y., Syracuse—The Syracuse Athletic Club, Inc., 312 South Warren St., plans to build an 8 story, 75 x 165 ft. clubhouse. About $500,000. W. W. Ward, Liverpool, Archt.

N. J., Jersey City—The Carteret Branch Trust Company of New Jersey, Hoboken, plans to build a bank building on Bergen Ave., here. About $300,000.

N. J., Newark—The Bd. Educ., Broad St., will soon receive bids for an addition to the Miller St. school, including a steam heating system. About $400,000. J. H. Ely, Broad and Market Sts., Archt. and Engr.

N. J., Newark—The Bd. Educ., Broad St., plans to construct a brick and stone school on Hawkins St., including a steam heating system. About $500,000. Architect not selected.

N. J., New Brunswick—The New Jersey College for Women is having sketches prepared for a dormitory. About $400,000. M. S. Douglas, 109 George St., Dean. Ludlow & Peabdoy, 101 Park Ave., New York City, Archts.

Pa., Elizabethtown—The Masonic Home will receive bids soon for a 3 story, 100 x 250 ft. hospital, including a steam heating system. E. A. Wightman, 1213 Filbert, Philadelphia, Archt.

Pa., Erie — The Buffalo & Lake Erie Traction Co., Exchange Bldg., is in the market for a 50 ft. used air compressor.

Pa., New Castle—The New Castle School District will receive bids until March 8 for a 2 story, 59 x 340 ft. and 146 x 193 ft. high school. Cost between $600,000 and $700,000. W. G. Eckles, Archt.

Pa., Philadelphia—Bnai Jesurum Congregation, c/o Herts & Robertson, Archts., 331 Madison Ave., New York City, is having plans prepared for a synagogue on Diamond St., here. About $300,000.

Pa., Philadelphia — The city is having plans prepared by J. T. Windrim, Archt., Commonwealth Bld., for a 4 story, structural steel municipal court building, on Vine, Race, 20th and 21st Sts. About $5,000,000.

Pa., Philadelphia—The Curtis Publishing Co., 6th and Walnut Sts., is having sketches prepared by A. W. Brunner, Archt., 101 Park Ave., New York City, for a 10 story publishing plant at 386 Chestnut St. A steam heating system will be installed. About $5,000,000.

D. C., Washington — B. S. Simmons, Archt., District Natl. Bank Bldg., is preparing plans for a 7 story apartment hotel. About $350,000. Owner's name withheld.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., plans to build radio buildings at Ocean Park, Wash., and at Astoria, Ore.

Va., Richmond—Liggett & Myers, 7th and Cary Sts., are in the market for a battery of 800 hp. boilers, turbine engine and dryer for their factory here. Address Purchasing Agent, 212 5th Ave., New York City.

W. Va., Charleston — The West Penn Electric Co., Pittsburgh, Pa., plans to develop the water power along the Cheat River, here, if the proper legislation is passed at the March session of the West Virginia Legislature. About $15,000,000. This project was started by the Kuhn interests in 1916 but was abandoned.

Fla., St. Augustine—The Commonwealth Hotel Co., 18 East 41st St., New York City, is having sketches drawn by Starrett & Van Vleck, Archts., 8 West 45th St., New York City, for a brick, steel and stone hotel building here, including a steam heating system. About $5,000,000.

Fla., St. Petersburg—The Williams-Beers Ice Co. is planning to build an ice plant. About $100,000. H. Beers, Engr.

Fla., Sutherland — Southern College is campaigning for funds to rebuild 2 burned buildings, to be 3 stories, 100 x 100 ft. each. About $400,000. Dr. R. H. Alderman, Pres.

O., Cheviot—St. Martin's Church will open bids soon for a 105 x 170 ft. church on Glenmore St. About $250,000. J. C. Grunkemeyer, 3717 Eastern Ave., Cincinnati, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., is having plans prepared for a 2 story junior high school on West 46th St., about $1,500,000, also a 2 story elementary school at Rawlings Annex, $500,000, and one on Parkview Rd., $450,000. Steam heating systems will be installed in same. A 2 story annex to school on Addison Rd., with extensions to steam heating system, is also planned, about $400,000. W. R. McCornack, c/o Bd. Educ., Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., is having plans prepared by W. R. McCornack, Archt., East 6th St. and Rockwell Ave., for a Senior High School in the Collinwood District. About $2,000,000.

O., Dayton—The Allsteel Ridewell Tire & Rubber Co., 513 Lindsay Bldg., plans to build a 3 story, 70 x 130 ft. tire factory on Dayton St. About $350,000. Osborn Eng. Co., 2848 Prospect Ave., Cleveland, Engr.

O., Dayton—The Dayton Power & Light Co., 4th and Jefferson Sts., plans to build a 4 to 6 story, 50 x 150 ft. office building at 4th and Wilkinson Sts. About $500,000. Architect not selected.

O., Freeport—The Crab Orchard Mining Co., Columbus Savings Trust Bldg., Columbus, is in the market for a 100-kw. generator, engine, and electric locomotive for coal mining, to be installed in new power plant here. E. E. Learned, Secy. and Mgr.

O., Glendale—The village plans to electrify the local waterworks. About $30,000. J. D. Lyon, Union Central Bldg., Cincinnati, Consulting Engr.

O., Massillon—The Masonic Temple Assn. is having sketches prepared for a 4 story, 150 x 87 ft. temple. About $500,000. C. W. King, Chn. Thayer & Thayer, Mercantile Bldg., New Castle, Pa., Archts.

O., Middletown—The Building Com. of the Y. M. C. A., c/o H. O. Miller, Chn., has employed S. Hannaford & Sons, Archts., 6th and 9th Sts., Cincinnati, to prepare plans for a 5 story Y. M. C. A. building. About $400,000.

O., Youngstown — Stanley & Scheible, Archts., 1301 Wick Bldg., will receive bids in the spring for a 6 story, 70 x 120 ft. hotel on West Boardman St., for Henry Dietz, c/o Imperial Hotel. About $250,000.

Ind., Delphi—The Farmers Co-operative Packing Co. plans to construct a packing plant here, including a power plant. About $500,000. Architect not selected.

Ind., Fort Wayne—The Fort Wayne Storage Co., Harrison and Grand Sts., will receive bids after March 1 for a 6 story, 100 x 200 ft. warehouse. A steam heating plant, including boilers, piping, etc., will be installed. About $500,000. Noted Oct. 26.

Ind., Frankfort—The city had specifications prepared for a 1 story, 100 x 100 ft. municipal light and power plant and bids will soon be received. Equipment, including boilers, stokers, turbines, condensers, coal and ash handling machinery, spray pond, etc., will be installed. About $275,000. J. D. Lyon, Union Central Bldg., Cincinnati, O., Engr. Noted Feb. 1.

Ind., Richmond—The city plans to purchase a centrifugal pump, coal and ash handling equipment, strainers and meters for its proposed new lighting plant. About $50,000. J. D. Lyon, 2513 Union Central Bldg., Cincinnati, Ohio, Engr.

Ind., Tippecanoe—J. A. Shafer, Engr., 310 Odd Fellows' Bldg., Indianapolis, representing the Tippecanoe Power Co., is having surveys made for the construction of 9 dams with an electric substation for each, along the Tippecanoe River. Cost between $6,000,000 and $7,000,000.

Mich., Detroit—The city, c/o W. H. Adams, Chn. of the Development Com., Bd. of Commerce, 1200 Vinton Bldg., is making tentative arrangements for a shipping port on the Detroit River, including warehouses, unloading and conveying equipment, etc.

Mich., Detroit—The Detroit City Mission, c/o D. S. Stucky, 710 Randolph St., plans to build a 4 story mission hotel, including a steam heating system. About $250,000. Architect not selected.

Mich., Detroit—The Knights of Columbus, 4732 Woodward Ave., plans to build an 8 story club house, including a steam heating system. About $2,000,000. Architect not selected.

Mich., Detroit—Park, Davis & Co., Atwater St. and McDougal Ave., will soon award the contract for a 7 story, 200 x 248 ft. drug factory, including a steam heating system. Power plant equipment will also be required. Smith, Hinchman & Grylls, 710 Washington Arcade, Archts. and Engrs. Noted Jan. 25.

Ill., Chicago—C. W. Christiansen, Archt., 845 Ainslie St., is preparing sketches and will open bids about March 1 for a 5 story, 50 x 100 ft. apartment hotel, including a steam heating system, on East Elm St. between North State St. and Lake Shore Drive. About $250,000. Owner's name withheld.

Ill., Chicago—Garfield Park Aerie No. 1113, 4258 West Monroe St., is having plans prepared and will receive bids about March 1 for a 4 story, 130 x 150 ft. hall building, including a steam heating system, at 5233 West Madison St. About $400,000. P. Gerhardt, 64 West Randolph St., Archt.

Wis., Fon du Lac—Bids are being received by B. E. Mehner, Archt., 6 East Division St., for various kinds of refrigeration machinery and insulation for the new dairy plant for the Fountain County Dairy Co., c/o R. Buetter, 218 South Main St. Power machinery and equipment will also be required.

Wis., Hartford—O. Webb, Archt., 544 49th St., Milwaukee, is preparing plans for a 5 story, 100 x 300 ft. theatre and office building, including a steam heating system. About $250,000. Owner's name withheld.

Wis., Janesville — The Bd. Pub. Wks. will soon award the contract for a 1 story, 18 x 40 ft. and a 22 x 30 ft. addition to the pumping station. A Murray pumping engine will be installed. C. V. Kerch, City Engr. Noted Jan. 18.

Wis., Kenosha—The Wisconsin Theatre Co., 172 Market St., is having plans prepared for a 3 story, 80 x 150 ft. theatre and office building. About $250,000. W. H. Pruyn, 122 South Michigan Ave., Chicago, Ill., Archt.

Wis., Racine—The School Bd. is having plans prepared for a 3 story, 85 x 185 ft. continuation school on Geneva St. About $250,000. J. J. Moritz, Secy. A. A. Guilbert, Robinson Blk., Archt.

Wis., Racine—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, are receiving bids for a steam jet ash conveyor for the Racine Mfg. Co., 6th and Wood Sts.

Wis., Stanley—The Bd. Educ. plans to build a junior high school, including a steam heating system. About $300,000. W. I. White, Supt. of Schools. Architect not announced.

Wis., Two Rivers—The Bd. Educ. will open bids about Feb. 21st for a 3 story, 115 x 199.6 ft. reinforced concrete and brick high school on Main St. Plans include a 50 x 74.10 ft. boiler house. About $400,000. John D. Chubb, 109 North Dearborn St., Chicago, Ill., Archt. Noted Dec. 21.

Wis., Two Rivers—St. Luke's Congregation, c/o Rev. J. A. Geissler, plans to build a 2 story, 50 x 150 ft. heating plant, including 4 boilers, underground conduits, etc. About $75,000. Engineer to be selected soon.

Ia., Ottumwa—The Bd. Educ. will receive bids until Feb. 23 for a 4 story, fireproof and brick high school, including a steam heating system. About $700,000. Croft & Boerner, 833 Palace Bldg., Minneapolis, Minn., Archts.

Iowa, Webster City—The School Bd., R. L. Cox, Pres., plans to build a junior high school. About $275,000. W. Gordon, 319 Hubbell Bldg., Des Moines, Archt.

Minn., Owatonna—The city voted against $475,000 bond issue for a municipal light, power, heat and gas plant. Noted Oct. 19.

Minn., Redwood Falls—The city, c/o H. C. Rutter, City Clerk, will receive bids until Feb. 24 for furnishing one 15 k. w. and one 20 k. w. current transformers and other apparatus, to be used in connection with the ornamental lighting system they plan to install. Total estimated cost, $18,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Engr.

Kan., Clay Center—The city voted $80,000 bonds for additional equipment for the municipal light and water plant, including boilers, feed water heater, switchboard, transformers, exciter set, etc. R. W. Callaway, Supt.

Kan., Hays—The First Methodist Episcopal Church plans to build a church and dormitory building. About $275,000. Architect not selected.

Neb., Lincoln—The School Bd. plans to build a 2 story school. About $400,000. Fiske & McGinnis, 533 Banker's Life Bldg., Archts.

Wyo., Douglas—The city will soon receive bids for the construction of a pump house, also furnishing pump and engine, and the laying of 1,800 ft. 12 in. pipe to connect the new layout with the town mains. This work in connection with extensions to the water system. F. T. Cummings, City Engr. Noted Dec. 21.

Mo., Columbia—The city will receive bids until Feb. 21 for furnishing one 1000 kw. turbo generator unit, switchboard and condenser. John S. Buckwell, City Clk.

Mo., St. Louis—The A. F. & A. Masons, 418 Olive St., plan to construct a hospital. About $1,000,000. Architest not selected.

Mo., St. Louis—The Bell Telephone Co. of Missouri, Boatmen's Bank Bldg., plans to build a 3 story, 105 x 150 ft. telephone exchange building, including a steam heating system, on 10th and Chestnut Sts. About $600,000. I. R. Timlin, Company Archt., W. O. Pennell, Chief Engr.

Mo., St. Louis—The Central Y. M. C. A. of St. Louis, 9th and Carr Sts., plans to build a Y. M. C. A. clubhouse at Grand and Franklin Sts. About $500,000. P. Bevis, Dir. Architect not selected.

Tex., Dallas—First Methodist Church had plans prepared for a 2 story, 265 x 265 ft. church, including a steam heating system, at Ross and Harwood Sts. About $400,000. J. S. Lee, Chn. of Bldg. Com. H. M. Greene & Co., North Texas Bldg., Archts.

Tex., Dallas—J. Jones and J. T. Jones are having plans prepared for a 3 story, 70 x 200 ft. theatre on Elm St. near St. Paul St. About $1,000,000. H. H. Hunt & Co., South Western Life Bldg., Archt.

Tex., Graham—The city is having plans prepared for constructing a dam on Salt Creek, enlarging pumping plant and filtration vats, etc. About $100,000. H. E. Elrod Eng. Co., Interurban Bldg., Dallas, Consulting Engrs.

Okla., Oklahoma City—The State had plans prepared for a state memorial hospital including a power plant. About $2,000,000. M. Jayne and C. Nieder, Oklahoma City, Associated Archts.

Cal., Los Angeles—The Bd. Supervs. of Los Angeles County will receive bids until Feb. 21st for furnishing and installing automatic oil stoking equipment for a boiler room.

Cal., Monrovia—J. H. McDowell is having plans prepared for a 5 story, 175 x 175 ft. hotel. About $400,000. H. B. Dunn, 6665 Hollywood Blvd., Los Angeles, Archt.

Que., Montreal—The Catholic Bd. of School Comrs., St. Catherine St., E., will receive bids about March 1 for a 3 story, 100 x 134 ft. school. About $285,000.

Que., Montreal — S. L. Constant, 1300 Papineau Ave., will soon award the contract for the construction of a 2 story, 78 x 99 ft. cold storage plant, on Marquette Ave. About $50,000.

Ont., Iroquois Falls—The Alitiba Power & Paper Co. plans to increase the capacity of its plant. About $250,000.

Ont., Ottawa—The Council of Carleton County will soon receive bids for the construction of a central heating unit to serve the county registry office, county jail and courthouse. About $75,000. Patterson & Byrne, 71½ Sparks St., Engrs.

Ont., Toronto—The Bd. Educ., 155 College St., will soon receive bids for furnishing two new horizontal tubular boilers, to be installed in the heating plant of the Central Technical School. About $15,000. W. W. Pearse, Mgr.

CONTRACTS AWARDED

N. Y., New York—J. Axelrod & Son, 200 West 72nd St., will build a 9 story apartment house, including a steam heating system, on West 76th St. About $250,000. Work will be done by day labor.

N. Y., New York—The Pandora Realty Co., 6 East 39th St., will build a 14 story apartment house, including a steam heating system, at 584 West End Ave. About $450,000. Work will be done by day labor.

N. Y., New York—The Rhinelander Real Estate Corp., c/o Maynicke & Franke, Archts., 25 Madison Ave., will build a 10 story apartment house, including a steam heating system, on Lexington Ave. and 90th St. About $750,000. Work will be done by day labor.

N. Y., New York—The U. S. Treasury Dept., Wash., D. C., has awarded the contract for a post office at 34-50 Varick St., here, to the Longacre Engr. & Constr. Co., 242 West 45th St. About $800,000.

Md., Annapolis—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., awarded the contract for boiler plant equipment and piping for the Naval Academy here, to H. A. Kries & Sons, 6 West Lombard St., New York City, at $54,020. Noted Jan. 25.

Fla., Pensacola — The Escambia Co. School Bd. has awarded the contract for a 3 story, 150 x 150 ft. school, to the McDervitt Fleming Co., Chattanooga, Tenn., at $269,490. A steam heating system will be installed in same.

O., Berea—The city has awarded the contract for two 250 hp. boilers, to the Connelly Boiler Co., Cleveland, at $18,737; pumps and condensers, to J. S. McGowan, Cleveland, at $5,820.

Ind., Hammond—Hammond Lodge, A. F. & A. M. has awarded the contract for a 3 story, 176 x 216 ft. lodge hall, to the J. W. Snyder Constr. Co., 122 South Michigan Ave., Chicago, Ill. A steam heating system will be installed in same. About $275,000.

Ind., Indianapolis—The Spink Hotel Co., 914 Hume Mansur Bldg., has awarded the contract for an 8 story, 142 x 202 ft., brick and concrete hotel on Meridian St., to E. G. Spink Co., 914 Hume Mansur Bldg. About $1,000,000.

Mich., St. Clair—The city has awarded the contract for furnishing and installing waterworks equipment, including 2 motor-driven centrifugal pumps of 700 gal. capacity, 50-hp. motor, 1,000-gal. pump, 6-cylinder gas engine, piping, small pump, etc., to Allis Chalmers Co., West Allis St., Milwaukee, at $9,832.

Ill., Chicago—G. M. Posner, 327 South La Salle St., will build a 9 story, 140 x 150 ft. reinforced concrete apartment house at 6801-13 Sheridan Rd. A steam heating system will be installed. About $1,500,000. Work will be done by day labor.

Tex., Terrel—The city has awarded the contract for filtration plant, including a pump house, filter system, oil engines and two pumps to Merkle Machinery Co., Tulsa, Okla., at $47,850.

Cal., Sawtelle—The U. S. Soldiers' Home has awarded the contract for two 2 story, 54 x 364 ft. hospital buildings, including a steam heating system, to Lange & Bergstrom, Timkin Bldg., San Diego, at $520,019. Noted Jan. 25.

Cal., Vernon—The Santa Fe R.R. Co., Kerchoff Bldg., Los Angeles, has awarded the contract for an 85 x 275 ft. ice plant at Hobart Station, here, to C. A. Fellows, Central Bldg., Los Angeles, at $500,000. Ice manufacturing machinery, conveyors and elevators will be required. Noted under Los Angeles, Jan. 25.

Ont., London — The Benson-Hines Hotel Co. has awarded the contract for a 10 story, 100 x 120 ft. hotel on Richmond St., to the Frid Constr. Co., Sun Life Bldg., Hamilton. Steam boilers, piping and radiation equipment will be required. About $1,000,000.

Ont., Windsor—The Bd. Educ. has awarded the contract for a 2 story school, including steam heating and ventilation control systems, to S. E. Dinsmore Co., Ltd., 7 Royal Bank Bldg., at $361,225. Noted Nov. 2.